ICMAT

INSTITUTO DE CIENCIAS MATEMÁTICAS

annual report

2018

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1. Introduction: The ICMAT and the Mathematization of Spain

Antonio Córdoba.

The title of this introduction is a tribute to an [article](#) by Salvador Montero published in 2007 in the journal ARBOR, which I recommend to anyone interested in learning about the fluctuating fortunes of scientific research in Spain. Among other things, Montero gives a full account of the work carried out by the Advisory Research Board on Science and Technology during the first government under Felipe González. Montero, who served as coordinator on the Board's panel for Physics and Mathematics (on which I was also a member), draws particular attention in his article to the precarious existence of mathematics in Spain as compared with other European countries, a situation that has existed since the reigns of the emperor Carlos V and king Felipe II until recent times. He illustrates his account with several examples that show how the lack of any mathematical culture severely hindered the development of science and technology in our country, to say nothing of its politics and economy.

Montero concluded his article with the following proposal addressed to the *Consejo Superior de Investigaciones Científicas* (CSIC – Spanish National Research Council), which at the time was being legally reconstituted from a Public Research Institution to a National Agency: "It might not be a bad idea to profit from this occasion by making some changes to Ramon Llull's Tree of Science, which is in fact the Council's logo, by removing Theology from the trunk and replacing it with Mathematics, the true foundation of both science and technology, to which the Council devotes its energies. Exchanging faith for reason ought to be the vital leitmotif of the new Agency, to which the newly emerging *Instituto de Ciencias Matemáticas* (ICMAT – Institute of Mathematical Sciences) ought to contribute in no small part, since this Institute is conceived as an ambitious joint centre consisting of the CSIC itself and the Complutense, Autonomous and Carlos III Universities in Madrid. This would make up for an anomaly that has taken years to rectify".

Twelve years later, we can now say to Salvador Montero that in its short life-span thus far the ICMAT has indeed contributed to the "mathematization" of Spain, and currently occupies a leading position as regards research in this scientific field. We could imagine the structure of mathematics in Spain as a pyramid in which education forms the base, knowledge-transfer as part of the trunk and research the apex. The interrelation and communication between these three strata are vital for the well-being of the system. The ICMAT finds its natural niche at that apex,

and I believe we can state, not without pride, that we have carried out some very fine work. We are good at resolving conjectures that have been the object of mathematical desire and at obtaining research results that are subsequently published in leading journals, as well as being successful in competitive projects, whether those offered by the Ministry, the European Research Council or the European Commission. Furthermore, some of our research groups, such as that devoted to Fluid Mechanics, enjoy worldwide recognition.

However, where Llull's Tree of Science is concerned, the change has been much more difficult and elusive, since debate still exists in the CSIC about whether or not mathematics really constitutes one of the basic fields in science.

One of the undertakings of the Panel coordinated by Salvador Montero was to bring together Spanish Mathematicians in Segovia between November 20th-22nd, 1986, in order to discuss the following issue: "Mathematical research: Its current state in Spain". One of the conclusions was a recommendation for the creation of a mathematical research institute, with the aim of facilitating and stimulating interaction among Spanish mathematicians and with the rest of the world. What form should such an institute take? Those attending the meeting in Segovia analyzed the characteristics of such institutes already in existence in other countries and which were the driving force for mathematical development in their respective areas of influence.

The Institute for Advanced Study (IAS) in Princeton is undoubtedly the archetype that has served as a model and has inspired the creation of many other such institutes: the IHES (France); the Max Planck Institute (Germany); the Newton Institute (United Kingdom); the De Giorgi (Italy) or the MSRI (United States). Created in 1930 with a us donation from philanthropists Caroline and Louis Bamberger, its brainchild and first director was Abraham Flexner, whose vision was revolutionary:

"The institute should be small and plastic (that is, flexible). It should provide a refuge where scientists can observe the world and its phenomena as in a laboratory, without being swept away by immediate concerns. It should be simple, comfortable and silent, without being either monastic or isolated. It should not be afraid of addressing any problem. However, its researchers should not be under any pressure that may predispose them either in favour or against any particular solution to problems in which they are engaged. The institute should provide the facilities, the peace and quiet and the time required for basic research into the unknown. Its members should be able to enjoy complete intellectual freedom and be relieved of all administrative duties and responsibilities".

Such ideas concerning the importance of enabling researchers to pursue their own intellectual curiosity without being burdened by bureaucratic tasks are far removed from the situation we have at the ICMAT, where the CSIC board requires "strategic plans" to be drawn up and participation in "platforms", in addition to an occasionally excessive bureaucratic workload.

Unfortunately, in Spain we remain entangled in an outmoded tradition that stretches back to the policies of the emperor Carlos V and his son, king Felipe II, who involved the country in European wars, making us the standard-bearers of ultramontane Catholicism and closing our frontiers to any influx of ideas arising from

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the scientific revolution, with the result that our universities of that period remained marginalized from the theories devised by Newton, Leibniz or the Bernoullis. Consider the pitiful anecdote concerning Felipe II (who at that time was the most powerful king on earth) and his complaint to the Pope that the French had deciphered his messages with the help of the Evil One, when he had not the least idea of the abilities of the algebraist Viète, and that of many others, who knew how to break the substitution codes. Some years later, during the reign of Felipe V, when permission to measure the meridian arc close to the Equator was granted in territories belonging to the Spanish Crown, it was necessary to call on the help of a 19 year-old naval officer, Jorge Juan, who was appointed as the Spanish representative in the expedition, with a promotion in rank in order to strengthen his authority with the seasoned scientists proposed by the French Academy. Although Jorge Juan obtained no original mathematical result, he was an intelligent young man who understood very well the task with which he was entrusted, and penned a delightful book on those measurements of the meridian arc that is one of our most prized possessions in the CFTMAT library (which is in fact named after this celebrated naval officer).

Enlightenment governments also failed to make things much better. They carried out some projects, such as the construction of the explosives factory in Segovia, which attracted the chemist Proust, but only on a short-term basis that sought immediate results, unlike the projects undertaken in Russia during the reign of Catherine the Great, for example, which drew the genius Euler to St. Petersburg and sowed the seed for the excellent Russian school of mathematics in the 19th century.

In Spain, in the meantime, the first Chair of Differential Calculus was established at the University of Salamanca. Norberto Cuesta Dutari, Professor of Mathematical Analysis at this university, scoured the archives in order to write a book on the subject. He told me that there were two candidates for the occupancy of this Chair, one of whom was Diego de Torres Villarroel. The decision for this appointment was based on the result of quaint exercises such as the *Piques del Almagesto*: one member of the selection committee opened a copy of the Almagest (a 2nd century Greek mathematical and astronomical treatise) at a random page, read the first paragraph out loud and asked the candidate to complete the rest. In this particular case, the examination went on for too long and the committee was unable to reach an agreement. Furthermore, when a decision was finally made, the losing candidate contested it, which led to a legal dispute that ended in the annulment of the decision and a repetition of the selection process. The situation caused such a scandal that the government of Carlos III was forced to intervene. The committee finally chose Diego Torres Villarroel, and the document confirming his appointment was endorsed by the king, although according to Cuesta it stated that neither of the candidates knew very much about differential calculus. In any event, the selection committee considered that Torres Villarroel was the candidate best qualified to learn about it, so he was provisionally appointed to the Chair on condition that he studied the subject in the University of Salamanca library.

This story serves as a damning indictment of the impoverished state of mathematics in Spanish universities at that time. The situation hardly improved at all in the 19th century, although we may mention the figure of Echegaray (professor of mathematics at the School of Civil Engineers) who, despite contributing no original results, at least kept himself up to date with the mathematics of his time. The address he delivered on his appointment to the Royal Academy of Sciences included a detailed rundown of the advances in mathematics achieved during the 17th and 18th centuries, and concluded with the following remark: "Mathematical science owes nothing to us. It is not ours, and no name worthy of mention in that field can convincingly be uttered on Spanish lips".

In the late 19th century (1887-88) a Spanish author published his results for the first time in a scientific journal of international prestige. They were entitled *Sur la géométrie non-euclidienne* and *Sur les propriétés graphiques des figures centriques* and appeared in Mathematische Annalen. Like Echegaray, the author, Ventura Reyes Prósper, had also completed his baccalaureate at the same school in the centre of Murcia (Instituto Alfonso X El Sabio). His personal library, which was donated to the *Junta de Ampliación de Estudios* (JAE) and eventually came to form part of the ICMAT collection, showed Ventura's interest in mathematical logic, a subject that was very much in vogue at that time.

The situation gradually improved, culminating in the creation of the JAE when, among others, the figure of Julio Rey Pastor emerged, together with his mathematical library, in the 1930s. However, the Civil War put an end to this endeavour, and what we encounter after this disaster sends shivers down the spine, as can be seen from these words, cited by Salvador Montero, spoken by the minister José Ibañez Martín in the address he gave on the foundation of the CSIC: "The imperial tree of Spanish science flourished in the garden of catholicity and did not neglect to graft into its trunk as the very nerve and fibre, the divine and sacred science, from whose sap at one and the same time all its leafy branches were nourished…". It was in this setting that within the CSIC the Instituto *Jorge Juan de Matemáticas* was created (and of which the ICMAT could be regarded as the successor), whose mediocre activity, on which it would perhaps be better not to dwell, was extinguished in the mid-1980s. It is enough to mention the comment made in the journal "Mathematical Reviews" in 1962 concerning the publications by one of the most conspicuous members of the aforesaid institute: "*Suite d'articles antérieurs dont la confusion extrême a été commentée dans ces Reviews avec une modération aussi extrême*" (Further to the foregoing articles, whose extreme confusion has been commented on in these Reviews with a correspondingly extreme moderation).

The minutes of the annual meetings of Spanish mathematicians (RAME), begun by the *Real Sociedad Matemática Española* (Royal Spanish Mathematical Society) in the early 1960s, include a record of conferences given on the state of mathematics in our country. In general, the tone is highly laudatory and uncritical, but very often the records contain interesting information about where we come from. In the inaugural address of the 5th RAME meeting, held in Sevilla in 1967, Antonio de Castro made the following statement: "It is not easy to bring Spanish mathematicians together, given the fact that in our national territory they are somewhat thin on the ground. Consider, for example, that in this entire region (Andalucía and Extremadura), for many years there has been only one university chair in mathematics, and to the best of my knowledge only a couple of mathematicians holding a doctorate in this field".

Going back to the 3rd RAME meeting, held in Barcelona in 1963, when analyzing his own experience in universities, Antonio Torroja wrote as follows: "My memories bring to mind, of course, the University of Madrid, where I completed my studies. When I arrived there, the field of exact sciences consisted of a group of professors (Jiménez Rueda, Octavio de Toledo, Vegas, etcétera). I didn't participate very much in their lectures, but I did study the articles published by them. Generally speaking, they were clearly and carefully written and showed an eagerness for improvement. However, the articles were exclusively inspired by French classical mathematics and gave no evidence of the advances being made beyond our own frontiers. Without doubt, this was due to the isolation of those worthy professors who, while being intelligent and enthusiastic, were not aware of the need to break with tradition and establish personal and constant contacts with mathematicians from abroad".

Starting in 1970, two factors began to change the situation substantially. First of all, the significant number of young Spanish mathematicians who left the country to do their doctoral and post-doctoral studies at prestigious universities abroad. Secondly, the increase in university posts that over the course of a few years have enabled many of these researchers to return. Since then, the change has been considerable. In order to prepare for the meeting in Segovia I mentioned above, I asked a group of students from the UAM to find out through the *Mathematical Reviews* the number of papers reviewed that were published by Spanish authors between 1960-80. At that time we had no digital database, so it was necessary to do this directly from hard copy publications, which meant that the results had to be regarded with a certain amount of caution. However, we discovered that only a mere 0.3% of the papers reviewed were by Spanish authors. If this figure is compared with the approximately 4.5% reviewed in 2012, perhaps we are justified in believing that the process of the mathematization of Spain is well and truly under way, but that it is also a very recent development.

There is no doubt whatever that the quality of education is a cornerstone in the mathematization of a country. Together with the study of the native tongue, mathematics plays a vital role in the education and development of the citizenry. It is ptecisely by means of elementary arithmetic and geometry that students can best be taught deductive reasoning, and thereby implant the operating system in the human brain. This is a difficult task that requires a great deal of support, both in the production of appropriate textbooks and in communicating to society the crucial role played by mathematics in the endeavour. Although it may not be one of our prime objectives, we at the ICMAT have lent our backing to this valuable undertaking. Through our Communication and Outreach Unit, we have collaborated with initiatives such as "Café y Teoremas", in the El País daily newspaper, or the "My favourite scientist" project, partly funded by the *Fundación Española para la Ciencia y la Tecnología* (FECYT). In any event, it is important never to lose sight of the fact that our status imposes its own restrictions; the ICMAT imprimatur means that those who disseminate must have *auctoritas*; that is, they should possess an extensive knowledge of the subject on which they write.

Finally, the trunk of the tree; knowledge-transfer. It is widely accepted that we stand on the threshold of the fourth industrial revolution in which the key world is "algorithm", and where the centaur formed by the mathematician and his or her computer constitute perhaps the most highly evolved specimen of contemporary technology. This explains the demand for mathematicians and computer engineers by industry, hospitals, financial institutions, telephone and security companies and big shopping centres. The changes that have taken place in the quality of students embarking on mathematical degree courses has been highly positive. The same may be said for the fact that a large collective of well-qualified mathematicians is engaged on these tasks, contributing with their knowledge to the smooth running and improved competitiveness of companies and businesses, and forming part of the increasingly necessary advisory bodies in matters of research and development.

The prosperity of the country depends on all the foregoing. Having said that: What is the role that an institute like the ICMAT should play in this regard? This is a very pertinent question that requires us to take stock of our strengths and calibrate our objectives. There is no doubt that mathematical problems arising from the business sector pose a real intellectual challenge and an incentive for the quality mathematical research that is our objective. Such problems should always be welcome, although the mere task of business consultancy is hardly the kind of work to be undertaken by a research institute.

All of this can be accommodated in an institute such as the ICMAT. But to that end it is necessary to learn Abraham Flexner's lesson well: what we need is a small and flexible research centre. Our institute aims to be an intellectual paradise, free of excessive bureaucracy and without elaborately detailed strategic plans that restrict researchers in their modes of thought. An "atomic" model with a small nucleus (faculty) but with a large "electronic cloud" consisting of members and visitors with a fresh turnover every year. A place in which intellectual curiosity and the demands (which are great) placed on researchers themselves constitute the daily work ethic, and where the goal is to extend the frontiers of mathematics by obtaining new theorems and theories, thereby making Echegaray's lament obsolete forever.
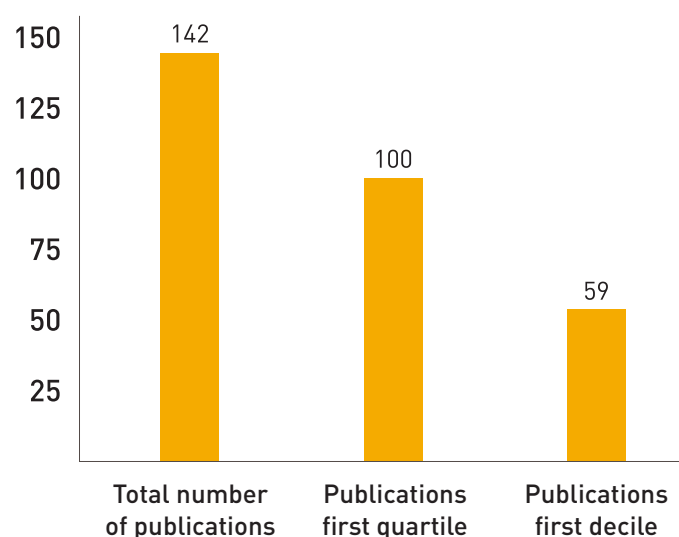
Antonio Córdoba, ICMAT director and professor of Mathematical Analysis at the Autonomous University of Madrid.

2. The ICMAT in figures

Personnel

Research personnel
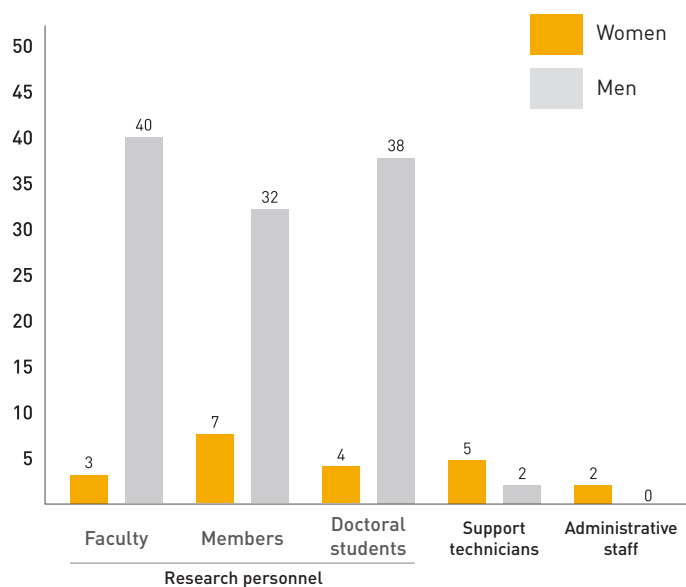
Publications

Women at ICMAT

	Total	Men	Women	% women
2018	145	126	19	13%

Projects

Events

Courses, Conferences and Work Groups	15
Colloquia UAM-ICMAT	7
Conferences and Schools	15
Thematic Trimesters	3
Theses	16
Escuela JAE 2018	1
Outreach Activities	8
Seminars	201
Junior	12
Geometry	35
Analysis and Applications	18
Applied Mathematics	14
Number Theory	23
Group Theory	32
DataLab	7
Commutative Algebra-Algebraic and Arithmetic Geometry UAM-ICMAT	9
PDEs and Fluid Mechanics	18
Q-Math	15
Others	18

Communication

Press releases	22
Noticias	37
Articles on Café y teoremas	39
Articles on the ICMAT Blog	9
ICMAT Newsletter bulletins	2
Followers on social media	
• Facebook	20 630 followers
• Twitter	21 442 followers
• Instagram	1400 followers
• Youtube	798 subscribers; 27 077 views
Outreach activities	15
Outreach materials	7

ICMAT funding

Projects: 2,333,725.71

Direct costs: 2,008,982.91, Indirec costs: 324,742.80,

Source:

- Private company: 11,434.69
- Europe: 1,028,266.32
- Out of UE: 32,762.84
- Spain: 1,277,588.63

ICMAT Expenditure

ICMAT BUDGET EXPENSES 2018	53,249.02
ICMAT PARTICIPATION IN CFTMAT 2018 BUDGET EXPENSES	286,708.51
	339,957.53

Expenses are distributed in accordance to the following:

PERSONNEL EXPENDITURE ON ICMAT PROJECTS IN 2018	**1,367,259.56**
MASTER GRANT EXPENDITURE 2018	**77,331.44**
EQUIPMENT, GOODS AND SERVICES EXPENDITURE IN ICMAT PROJECTS 2018	**656,780.68**
	2,101,371.68

PROJECT	PRINCIPLE RESEARCH	DIRECT COSTS	INDIRECT COSTS	TOTAL	FUNDING ENTITY
CONTRACT 20171723	DAVID RIOS	9,645.55	1,789.14	11,434.69	PRIVATE COMPANY
ERC RESTRICTION	KEITH ROGERS	95,460.75	17,504.70	112,965.45	UE-ERC
ONR1_2017	ANA MARIA MANCHO	24,258.59	8,504.25	32,762.84	ONR-USA
CYBECO	DAVID RIOS	74,413.64	13,766.49	88,180.13	UE
MTM2017-85934-C3-1-P	KEITH ROGERS	1,725.00	268.07	1,993.07	MICIU
MTM2017-89423-P	MARCO FONTELOS	5,925.00	920.75	6,845.75	MICIU
MTM2017-89976-P	DIEGO CORDOBA	10,625.00	1,651.13	12,276.13	MICIU
MTM2017-86875-C3-1-R	DAVID RIOS	2,660.00	413.16	3,073.16	MICIU
GEOFLUIDS	ALBERTO ENCISO	243,488.97	55,382.86	298,871.83	UE-ERC
NONFLU	DIEGO CORDOBA	458,988.23	92,171.31	551,159.54	UE-ERC
HAPDEGMET	JOSÉ MARÍA MARTELL	37,477.96	6,622.80	44,100.76	UE-ERC
IMPRESSIVE	ANA MARIA MANCHO	105,789.00	19,570.97	125,359.97	UE
MTM2015-72907-EXP	ANTONIO GOMEZ CORRAL	14,225.00	2,211.07	16,436.07	MICIU
MTM2015-72876-EXP	FRANCISCO PRESAS	8,535.00	1,326.34	9,861.34	MICIU
SEV2015-0554	DIEGO CORDOBA	869,565.22	96,521.74	966,086.96	MICIU
RTC2017-06593-7	DAVID RIOS	15,540.00	1,353.46	16,893.46	MICIU
MTM2016-76072-P	DAVID MARTIN	10,780.00	1,675.21	12,455.21	MICIU
MTM2016-79400-P	JOSE IGNACIO BURGOS	12,420.00	1,930.07	14,350.07	MICIU
MTM2016-81408-P	OSCAR GARCÍA PRADA	7,460.00	1,159.28	8,619.28	MICIU
		2,008,982.91	**324,742.80**	**2,333,725.71**	

3. Personnel

Chema Martell

2018 began with the appointment of Antonio Córdoba as director of the ICMAT. José María Martell (deputy director) and David Pérez and Francisco Presas (directors of the Department of Applied Mathematics and of Fundamental Mathematics, respectively) completed the leadership team.

In the last quarter of 2018, the ICMAT Governing Committee initiated the appointment process to the Institute of permanent researchers belonging to the Madrid Autonomous, Carlos III and Complutense Universities. This process, which was not concluded until early 2019, was conducted the following committee of experts appointed by the ICMAT executive team and the ICMAT Board, together with each of the three universities in partnership:

- María Jesús Carro (Universidad de Barcelona)
- José A. Carrillo de la Plata (Imperial College, United Kingdom)
- Marco Castrillón (UCM)
- Oscar García-Prada (ICMAT) - chair
- Eva Miranda (Universidad Politécnica de Cataluña)
- José Niño Mora (UC3M)
- Javier Parcet (ICMAT) - secretary
- Francisco Santos (Universidad de Cantabria)
- Jesús Sanz Serna (UC3M)

This committee was responsible for evaluating the applicants and for providing a list of the selected researchers, which was first approved by the ICMAT Board and then ratified by the ICMAT Governing Committee. This list is composed of 43 researchers: 18 from the CSIC, 12 from the UAM, 10 from the UCM and 3 from the UC3M.

As regards new contracts and personnel, 2018 was especially positive in terms of ICMAT personnel. On the one hand, Pedro Tradacete took up his post at the CSIC as Distinguished Researcher in the autumn. This post, together with that of Senior Scientist, the call for which was issued in last summer and will be occupied by Javier Aramayona throughout 2019, will mean that the ICMAT will have 18 researchers belonging to the CSIC. On the other hand, José María Martell was promoted in 2018 and occupies the post of Scientific Researcher.

33 new research contracts were signed at the ICMAT in 2018, 16 of which were postdoctoral appointments, nine (FPI, FPU, SO…) predoctoral and seven master students. On the other hand, a total of 21 researches finalized their contracts in 2018, without opting for a further contract in the same year.

In the area of Administrative Management, Esther Ruiz joined the Technical Support Team at the beginning of the year on a 3-year contract, during which she will provide administrative support, mainly in the area of National projects, Event Organization and Research Group Management. Laura Moreno Iraola was hired to continue her work at the Communication and Outreach Office after concluding her work-practice with *Garantía Juvenil*. Alfredo Caso left the ICMAT in the spring and was replaced by Alfonso Núñez, one of whose main duties is maintenance of the computer cluster.

Chema Martell, ICMAT deputy director.

Research groups

The ICMAT is made up of nine research groups, as detailed below.

Group 1. Mathematical analysis

The Institute has several researchers working in this research line across a wide range of topics, perhaps the most significant being those who are engaged in harmonic analysis. This is a highly active group that enjoys international recognition and has three projects from the European Research Council (ERC) concerning different aspects of harmonic analysis. Many other branches of analysis are also well represented in this group.

Members: 10 permanent researchers; 6 postdocs; 6 predocs.

In 2018, researchers from this group organized the research trimester on "Real Harmonic Analysis and its Applications to Partial Differential Equations and Geometric Measure Theory", which was held at the ICMAT between May and June. Its publications this year have appeared in journals such as the "Journal of the European Mathematical Society" and "Geometric and Functional Analysis". Moreover, the researchers were speakers at the conferences held at the Mittag-Leffler Institute and the Oberwolfach Institute. They also participated as assessors on international committees and were awarded grants from the Spanish Ministry for Science, Research and Universities for research stays abroad.

Group 2. Differential equations and applications

The differential equations and applications group works on both the development of the theory of differential equations and on its applications to fluid mechanics, mathematical physics and mathematical biology. The members of this group cover a broad spectrum of topics ranging from the approach of multidisciplinary mathematics to resolving problems to the promotion of applications through collaboration with other departments of engineering, biology, physics and earth sciences.

Members: 9 permanent researchers; 4 postdocs; 4 predocs.

In 2018, this group gained the first ERC Advanced Grant awarded to the ICMAT, while one of its members gave an invited talk at the International Congress of Mathematicians in Río de Janeiro. The group also obtained a Europa Excellence project from the Spanish Ministry for Science, Innovation and Universities. The group's results have been published in journals such as the "Journal of the European Mathematical Society" and "Transactions of the American Mathematical Society".

Group 3. Statistics, Probability and Operations Research (SPOR)

The SPOR group consists of mathematicians engaged in stimulating interdisciplinary research and exploring new, complex contexts for the use of applied probability, data science, machine learning, statistics and operational research for modelling, estimating, predicting and supporting decision-making and its uses in industry. The members of the SPOR group are closely connected with the ICMAT AXA Chair in Adversarial Risk Analysis and the DataLab, and provide statistical support to other CSIC institutes and non-academic partners, with a focus on big data and the large-scale analysis of scientific and business applications.

Members: 1 Axa Chair; 3 visiting professors; 6 postdocs; 5 predocs; 1 administrative employee; 2 technicians.

The SPOR (Statistics, Probability and Operations Research) group has received funding from the Ministry (Challenges, Challenges-Collaboration and Explore), from the European Union (H2020-CYBECO) and from companies such as A3Sec and Blueliv. Their main fields of work have been Risk Analysis and Adversarial Risk Analysis (ARA), with applications to security, cyber security and stochastic models in mathematical biology, frequently on large-scale problems (big data). Its members were awarded the DeGroot Prize, the most important distinction in Bayesian Statistics, and were also finalists in the DA Practice Award and the INFORMS Edelman Award, for their work on aviation safety. They also organized the "Young Behavioural Operational Research Workshop" at the Royal Academy of Sciences. Their main result concerns a new perspective on the adversarial classification problem based on ARA, which could change the approach to this problem that has exercised researchers for more than fifteen years.

Group 4. Algebraic geometry and mathematical physics

This group is devoted to the study of moduli spaces and their relation with different geometric structures. This study involves the use of ideas of algebraic geometry, differential geometry, topology and theoretical physics. The main threads of the group's activities concern the Donaldson-Hitchin Laboratory and the i-Link Collaboration, backed up by the exchange of researchers among the ICMAT, the University of Hong Kong and the University of Tsinghua.

Members: 7 permanent researchers; 2 postdocs; 3 predocs.

In 2018, the group organized a research programme on moduli spaces and two seminars. Its members were invited to international conferences in different parts of the world: China, Germany, France, the Netherlands, Italy, Argentina, the United Kingdom... All together, they have published some twenty research articles, some of them in leading journals in the field.

Grupo 5. Differential geometry and geometric mechanics

The research work pursued by this group consists of four main lines. The first deals with different aspects of differential topology, such as Engel structures, foliations and extensions of the h principle and contact topology. The second is focused on differential and Riemannian geometry; in particular, spectral problems, Poisson and symplectic geometry, field theory, Khaler geometry, geometric analysis and the geometric theory of information. The third is devoted to the study of geometric mechanics and control theory, including geometric integration, the Hamilton-Jacobi theory and continuation in classical mechanics. Finally, the fourth line concerns the theory of dynamical systems and the geometry of partial differential equations; specifically, topological fluid mechanics, KAM theory and its applications, and the study of sets of levels of solutions for elliptic and parabolic partial differential equations.

Members: 7 permanent researchers; 2 visiting professors; 5 postdocs; 10 predocs.

In 2018, the members of this group obtained important results that were published in journals such as the "International Mathematics Research Notices" and the "Journal of the European Mathematical Society". In addition, they were responsible for the organization of events such as the "60 Years Alberto Ibort Fest - Classical and Quantum Physics: Geometry, Dynamics and Control" conference, which was held in September of that year, and the "12th International ICMAT Summer School on Geometry, Mechanics and Control", which is held annually. Students who have trained in the group, such as Álvaro del Pino, have received the BBVA Foundation and the Royal Spanish Mathematical Society (RSME) Vicent Caselles Award in recognition of their theses.

Group 6. Mathematics of quantum information: foundations and applications

Quantum technologies currently constitute one of the most promising developments for the near future. They explore the quantum effects for the development of new techniques in fields such as cryptography, metrology, materials science and pharmacology. The ICMAT "Mathematics of quantum information" group works on a wide variety of mathematical problems, motivated by the design of quantum technologies.

Members: 4 permanent researchers; 3 predocs.

In 2018, the members of this group were recognized by institutions such as the Royal Academy of Sciences and the RSME. They received funding from the Community of Madrid and the MICINN to support their research work. They organized international conferences such as "60 Years Alberto Ibort Fest - Classical and Quantum Physics: Geometry, Dynamics and Control" as well as courses for doctoral students and the early stages of postdoc students.

This group is closely associated with the Ignacio Cirac ICMAT Laboratory, which has enabled some of its members to visit international research centres as well as participating in activities and collaborating with the Cirac team.

Group 7. Mathematical modelling and simulation

LThe activities of this group range from the multidisciplinary mathematical approach to real problems, with emphasis on numerical computation, to the promotion of applications through collaborations with other engineering, biology, physics and earth sciences departments around the world.

Its members conduct three lines of research: Microfluid modelling and technological applications; geophysical fluid dynamics, and stochastic and analytical methods in applied mathematics.

Members: 3 permanent researchers; 4 postdocs, 1 predoc.

2018 saw the launching of IMPRESSIVE, an innovative initiative that forms part of the EU Industrial Leadership Horizon 2020 scheme for the observation of the Earth from space, in order to develop a monitoring platform to detect dumping or spillage in ports or coastal environments. Also in 2018, the group published articles in journals such as "Scientific Reports" and "Physical Review Letters".

Group 8. Group theory

The research work of this group is devoted to different combinatory, geometric and algebraic properties of finite and infinite groups. Special attention is given to asymptotic group theory (for example, L2 invariants and growth functions), geometric group theory (such as nonpositive curved groups and mapping groups), profinite groups and representation theory.

The group collaborates closely with other researchers, both national and international (in particular, in France, Italy, Israel, the United Kingdom and the USA, etc). Its members organize a weekly research seminar attended by speakers from all over the world.

Members: 3 permanent researchers; 1 postdoc, 2 predocs.

In the first semester of 2018, the group organized an international thematic programme on "L2 Invariants and their analogues with positive characteristic", which included various conferences, schools and talks.
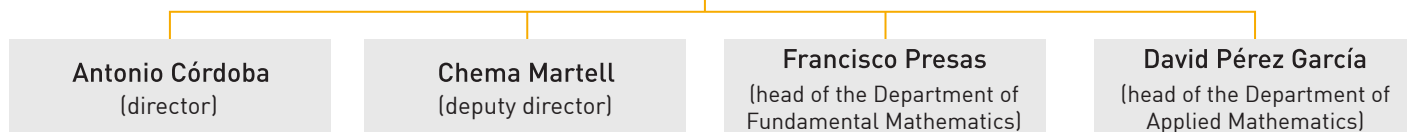
Group 9. Number theory

This group studies arithmetical problems from an interdisciplinary perspective using harmonic analysis, combinatory, probability theory, algebraic geometry, ergodic theory and even theoretical physics techniques. Its members are interested in different questions concerning the applications of harmonic analysis to additive combinatorics; the study of rational points of varieties; the Birch and Swinnerton-Dyer conjecture and the equivariant Tamagawa number conjecture; p-adic analysis and Arakelov theory.

Its members collaborate with the Autonomous University of Madrid with the organization of a weekly study group, as well as regular seminars on different topics in number theory. Furthermore, they collaborate with researchers from other national and international universities and institutions as well as exchanges with these centres.

In 2018, the members of this group published their results in journals such as the *Journal fur die reine und angewandte mathematik*. They participated in the organization of activities at other institutions such as the University of Copenhagen. They also set up schemes promoting initiation into research in number theory for baccalaureate students, such as "Numbers before Christmas".

Executive Team

Antonio Córdoba (director)	Chema Martell (deputy director)	Francisco Presas (head of the Department of Fundamental Mathematics)	David Pérez García (head of the Department of Applied Mathematics)

ICMAT Board

Antonio Córdoba	Chema Martell	Francisco Presas	David Pérez García
Ana María Mancho	Daniel Peralta	Javier Parcet	Miguel Anchuelo (secretary)

Antonio Córdoba

Chema Martell

Francisco Presas

David Pérez García

Ana María Mancho

Daniel Peralta

Javier Parcet

Miguel Anchuelo

Support technicians

Throughout 2018, the ICMAT has been able to count on a team devoted to supporting the research work, aided by personnel belonging to the CFTMAT charged with administrative and business management (human resources, accounting and financial matters), and also by the Library. As is now customary, the **Administration Office** has assisted researchers with their travel arrangements and expenses, together with help in the organization of the more than 15 scientific conferences held at the Institute. From the beginning of the year, Esther Ruiz has held at this office a Technical Support post with a 3-year contract.

In May, 2018, Alfonso Núñez joined the team as the person responsible for computer infrastructure at the ICMAT **Information Technology Office**. It his thanks to his efforts that the CFTMAT cluster has increased its number of users, thereby reaching an infrastructure use of more than 70%. In 2018, the IT team provided support for researchers in the creation of an events website, the updating of website content, purchasing management, corporate mail, and the development of intranet applications, etc. Likewise, together with the Institute of Theoretical Physics, Núñez coordinated the Software Carpentry (November 28th-30th), a practical workshop aimed at researchers of all levels covering IT concepts and tools applied to research. In addition, funding of 100,000 euros was negotiated and received from the ERDF (European Regional Development Fund) for extending the ICMAT computing equipment.

For its part, the **European Office** has assisted ICMAT researchers in their applications to international calls issued by public and private entities. In 2018, ICMAT members submitted 13 projects to the H2020 programme, 30.8% of which have received funding. In addition, proposals were submitted to other international calls (AXA Research Fund, Simons Foundation). Also in 2018, a further four projects were launched: among them the new European Council Advanced Grant and an innovation project for the H2020 Industrial Leadership scheme. In addition to the 15 projects already under way, the Office organized an informative session on European opportunities and drew up more than ten informative guides for the application of projects.

Among other tasks in 2018, the office for the management of the **Severo Ochoa Programme** coordinated activities organized to assist all the management, administrative, IT and communication personnel involved in this programme. Applications for funding and contracting, both internal and external, were also carried out. The intermediate financial rationale was also conducted during this period as well as the coordination of the intermediate scientific-technical rationale of the Severo Ochoa Programme submitted in 2018.

The **Communication and Outreach Office** has undertaken new projects for the popularization of mathematics to complement the usual talks and workshops, among which we may mention a new cartoon series on Youtube, "*Revoluciones matemáticas*", aimed at secondary school students. The *Café y Teoremas* section continues to open a window every week on different mathematical stories (biographies of mathematicians, research results, the contributions of mathematics to other disciplines...) in the El País daily. The media receive the latest news from the ICMAT (the latest advances in research at the Institute and important scientific and outreach events) by means of press releases, news items and the biannual newsletter. Within the framework of the ICMAT Gender Plan, the "My favourite female scientist" project has concluded its second edition with a greater participation and a final book that is more attractive in terms of design and content. Three new titles have been published in the *Miradas matemáticas* series, a collection that combines mathematical outreach with didactics. On completion of her work-practice contract on the *Garantía Juvenil* scheme, Laura Moreno Iraola has been hired for the Severo Ochoa Programme.

As an addition to these offices, Marta Sanz González (ICMAT-CSIC) was also appointed in an administrative role for the David Ríos AXA Project.

4. Main scientific results

The scientific production by researchers at the ICMAT in 2018 exceeded 140 publications, 100 of which are in the first quartile. The following list contains the results obtained by researchers and published in journals belonging to the first decile, classified as such by the Journal Citation Reports (JCR), the Web of Science (WOS), and/or by the Scimago Journal & Country Rank.

On the polynomial Wolff axioms

Title: "On the polynomial Wolff axioms"

Authors: Katz, Nets H.; Rogers, Keith M.

Source: *Geometric and functional analysis*, 28 (6), pp 1706-1716

Date of publication online: September, 2018

Link: https://link.springer.com/article/10.1007/s00039-018-0466-7

Summary: We confirm a conjecture of Guth concerning the maximal number of δ-tubes, with δ-separated directions, contained in the δ-neighborhood of a real algebraic variety. Modulo a factor of δ–ε, we also prove Guth and Zahl's generalized version for semi-algebraic sets. Although the applications are to be found in harmonic analysis, the proof will employ deep results from algebraic and differential geometry, including Tarski's projection theorem and Gromov's algebraic lemma.

Continuum limits of matrix product states

Title: "Continuum limits of matrix product states"

Authors: De las Cuevas, Gemma; Schuch, Norbert; Pérez-García, David; Cirac, J. Ignacio.

Source: *Physical review b. 98 - 17, Amer physical SOC*, 19/11/2018. ISSN 2469-9950, ISSN 2469-9969

Date of publication online: November, 2018

Link: https://journals.aps.org/prb/abstract/10.1103/PhysRevB.98.174303

Summary: We determine which translationally invariant matrix product states have a continuum limit, that is, which can be considered as discretized versions of states defined in the continuum. To do this, we analyze a fine-graining renormalization procedure in real space, characterize the set of limiting states of its flow, and find that it strictly contains the set of continuous matrix product states. We also analyze which states have a continuum limit after a finite number of coarse-graining renormalization steps. We give several examples of states with and without the different kinds of continuum limits.

Nonlinear profile decomposition for the H. 1/2 × H.(−1/2) (R-d) energy subcritical wave equation

Title: "Nonlinear profile decomposition for the H. 1/2 × H.(−1/2) (R-d) energy subcritical wave equation"

Author: Ramos, Javier.

Source: *Journal of functional analysis*. 275 - 10, pp. 2614 - 2646. Academic Press Inc Elsevier Science. ISSN 0022-1236, ISSN 1096-0783

Date of publication: September, 2018.

Link: https://www.sciencedirect.com/science/article/pii/S0022123618303264

Summary: We consider a nonlinear wave equation in dimensions d≥2. This equation is critical in some points and subcritical with respect to the energy. We prove the nonlinear profile decomposition. The proof must address the lack of compactness due to the Lorentz symmetry.

Normal projected entangled pair states generating the same state

Title: "Normal projected entangled pair states generating the same state"

Authors: Molnar, Andras; Garre-Rubio, José; Pérez-García, David; Schuch, Norbert; Cirac, J. Ignacio.

Source: *New journal of physics. 20,* IOP Publishing Ltd. ISSN 1367-2630

Date of publication: November, 2018.

Link: https://iopscience.iop.org/article/10.1088/1367-2630/aae9fa

Summary: Tensor networks (TNs) are generated by a set of small rank tensors and define many-body quantum states in a succinct form. The corresponding map is not one-to-one: different sets of tensors may generate the very same state. A fundamental question in the study of TNs naturally arises: what is then the relation between those sets? The answer to this question in one-dimensional setups has found several applications, like the characterization of local and global symmetries, the classification of phases of matter and unitary evolutions, or the determination of the fixed points of renormalization procedures. Here we answer this question for projected entangled pair states in any dimension and lattice geometry (including, for example, the Kagome lattice, hyperbolic lattices, or tree tensor networks), as long as the tensors generating the states are normal, which constitute an important and generic class.

Critical networked infrastructure protection from adversaries

Title: "Critical networked infrastructure protection from adversaries"

Authors: Quijano, Eduardo G.; Ríos Insua, David; Cano, Javier.

Source: *Reliability engineering & system safety*. 179, pp. 27 - 36. Elsevier Sci Ltd, ISSN 0951-8320, ISSN 1879-0836.

Date of publication: November, 2018.

Link: https://www.sciencedirect.com/science/article/pii/S0951832016307037

Summary: We use the adversarial risk analysis (ARA) framework to deal with the protection of a critical networked infrastructure from the attacks of intelligent adversaries. We deploy an ARA model for each relevant element (node, link, hotspot in link) in the network, using a Sequential Defend–Attack–Defend template as a reference. Such ARA models are related by resource constraints and result aggregation over various sites, for both the Defender and the Attacker. As a case study, we consider the protection of a section of the Spanish railway network from a potential terrorist attack.

Durfee rectangles and Pseudo-Wronskian equivalences for Hermite polynomials

Title: "Durfee rectangles and Pseudo-Wronskian equivalences for Hermite polynomials "

Authors: Gómez-Ullate, David; Grandati, Yves; Milson, Robert.

Date of publication: November, 2018.

Link: https://onlinelibrary.wiley.com/doi/abs/10.1111/sapm.12225

Summary: We derive identities between determinants whose entries are Hermite polynomials. These identities have a combinatorial interpretation in terms of Maya diagrams, partitions and Durfee rectangles, and serve to characterize an equivalence class of rational Darboux transformations. Since the determinants have different orders, we analyze the problem of finding the minimal order determinant in each equivalence class, and describe the solution using an elegant graphical interpretation. The results are applied to provide a more efficient representation for exceptional Hermite polynomials and for rational solutions of the Painlevé IV equation. The latter are expressed in terms of the Okamoto and generalized Hermite polynomials.

Extinction for a singular diffusion equation with strong gradient absorption revisited

Title: "Extinction for a singular diffusion equation with strong gradient absorption revisited"

Authors: Iagar, Razvan Gabriel; Laurencot, Philippe.

Date of publication: November, 2018.

Link: https://www.degruyter.com/view/j/ans.2018.18.issue-4/ans-2018-0002/ans-2018-0002.xml

Summary: When $2N/(N+1)<p<2$ and $0<q<p/2$, non-negative solutions to the singular diffusion equation with gradient absorption vanish after a finite time. This phenomenon is usually referred to as finite-time extinction and takes place provided the initial condition u0 decays sufficiently rapidly as $|x|\to\infty$. On the one hand, the optimal decay of u0 at infinity guaranteeing the occurrence of finite-time extinction is identified. On the other hand, assuming further that $p-1<q<p/2$, optimal extinction rates near the extinction time are derived.

The Biot–Savart operator of a bounded domain

Title: "The Biot-Savart operator of a bounded domain"

Authors: Enciso, Alberto; García-Ferrero, M. Ángeles; Peralta-Salas, Daniel.

Date of publication: November, 2018.

Link: https://www.sciencedirect.com/science/article/pii/S0021782417301800

Summary: We construct the analog of the Biot–Savart integral for bounded domains. Specifically, we show that the velocity field of an incompressible fluid with tangency boundary conditions on a bounded domain can be written in terms of its vorticity using an integral kernel that has an inverse-square singularity on the diagonal.

A framework for risk management decisions in aviation safety at state level

Title: "A framework for risk management decisions in aviation safety at state level"

Authors: Ríos Insua, D.; Alfaro, C.; Gómez, J.; Hernández-Coronado, P.; Bernal, F.

Date of publication: November, 2018.

Link: https://www.sciencedirect.com/science/article/pii/S0951832016309395

Summary: Aviation is a key industrial sector for global development. Safety is essential for its healthy growth. However its management is pervaded by simplistic methods based on risk matrices. We provide here a framework for risk management decisions in aviation safety at state level. This helps us in identifying the best portfolio that a state agency may implement to improve aviation safety in a country. We illustrate our proposal with a case study.

Dynamic of plumes and scaling during the melting of a Phase Change Material heated from below

Title: "Dynamic of plumes and scaling during the melting of a Phase Change Material heated from below"

Authors: Madruga, Santiago; Curbelo, Jezabel.

Date of publication: November, 2018.

Link: https://www.sciencedirect.com/science/article/pii/S0017931017356569

Summary: We identify and describe the main dynamic regimes occurring during the melting of the PCM n-octadecane in horizontal layers of several sizes heated from below. This configuration allows to cover a wide range of effective Rayleigh numbers on the liquid PCM phase, up to 10^9, without changing any external parameter control. We identify four different regimes as time evolves: (i) the conductive regime, (ii) linear regime, (iii) coarsening regime and (iv) turbulent regime. The first two regimes appear at all domain sizes. However the third and fourth regime require a minimum advance of the solid/liquid interface to develop, and we observe them only for large enough domains. The transition to turbulence takes places after a secondary instability that forces the coarsening of the thermal plumes. Each one of the melting regimes creates a distinct solid/liquid front that characterizes the internal state of the melting process. We observe that most of the magnitudes of the melting process are ruled by power laws, although not all of them. Thus the number of plumes, some regimes of the Rayleigh number as a function of time, the number of plumes after the primary and secondary instability, the thermal and kinetic boundary layers follow simple power laws. In particular, we find that the Nusselt number scales with the Rayleigh number in the turbulent regime, consistent with theories and experiments on Rayleigh-Bénard convection that show an exponent.

Every positive integer is a sum of three palindromes

Title: "Every positive integer is a sum of three palindromes"

Authors: Cilleruelo, Javier; Luca, Florian; Baxter, Lewis.

Date of publication: November, 2018.

Link: https://www.ams.org/journals/mcom/2018-87-314/S0025-5718-2017-03221-X/home.html

Summary: For integer g bigger or equal to 5, we prove that any positive integer can be written as a sum of three palindromes in base g.

Minimal graphs with micro-oscillations

Title: "Minimal graphs with micro-oscillations"

Authors: Enciso, Alberto; García-Ferrero, M. Ángeles; Peralta-Salas, Daniel.

Date of publication: October, 2018.

Link: https://www.sciencedirect.com/science/article/pii/S00022039618301141

Summary: We show that there are minimal graphs in whose intersection with the portion of the horizontal hyperplane contained in the unit ball has any prescribed geometry, up to a small deformation. The proof hinges on the construction of minimal graphs that are almost flat but have small oscillations whose geometry we can control.

On the essential minimum of Falting's height

Title: "On the essential minimum of Faltings' height"

Authors: Burgos Gil, José Ignacio; Menares, Ricardo; Rivera-Letelier, Juan.

Date of publication: September, 2018.

Link: https://www.ams.org/journals/mcom/2018-87-313/S0025-5718-2018-03286-0/S0025-5718-2018-03286-0.pdf

Summary: We study the essential minimum of the (stable) Faltings' heighton the moduli space of elliptic curves. We prove that, in contrast to the Weil height on a projective space and the Néron-Tate height of an abelian variety, Faltings' height takes at least two values that are smaller than its essential minimum. We also provide upper and lower bounds for this quantity that allow us to compute it up to five decimal places. In addition, we give numerical evidence that there are at least four isolated values before the essential minimum. One of the main ingredients in our analysis is a good approximation of the hyperbolic Green function associated to the cusp of the modular curve of level one. To establish this approximation, we make an intensive use of distortion theorems for univalent functions. Our results have been motivated and guided by numerical experiments that are described in detail in the companion files.

Optimal existence classes and nonlinear-like dynamics in the linear heat equation in R-d

Title: "Optimal existence classes and nonlinear-like dynamics in the linear heat equation in R-d"

Authors: Robinson, James C.; Rodríguez-Bernal, Anibal.

Date of publication: Agust, 2018.

Link: https://www.sciencedirect.com/science/article/pii/S0001870818302408

Summary: We analyse the behaviour of solutions of the linear heat equation for initial data in the classes of Radon measures. We show that these classes are optimal for local and global existence of non-negative solutions: in particular consists of those initial data for which a solution of the heat equation can be given for all time using the heat kernel representation formula. We prove existence, uniqueness, and regularity results for such initial data, which can grow rapidly at infinity, and then show that they give rise to properties associated more often with nonlinear models. We demonstrate the finite-time blowup of solutions, showing that the set of blowup points is the complement of a convex set, and that given any closed convex set there is an initial condition whose solutions remain bounded precisely on this set at the 'blowup time'. We also show that wild oscillations are possible from non-negative initial data and that one can prescribe the behaviour of u (0, t) to be any real-analytic function.

The foliated Weinstein conjecture

Title: "The foliated Weinstein conjecture"

Authors: del Pino, Álvaro; Presas, Francisco.

Date of publication: Agust, 2018.

Link: https://academic.oup.com/imrn/article/2018/16/5148/3074899

Summary: A foliation is said to admit a foliated contact structure if there is a codimension 1. distribution in the tangent space of the foliation such that the restriction to any leaf is contact. We prove a version of the Weinstein conjecture for Reeb vector fields in the presence of an overtwisted leaf. The result is shown to be sharp.

Weighted Sobolev spaces: Markov-type inequalities and duality

Title: "Weighted Sobolev spaces: Markov-type inequalities and duality"

Authors: Marcellán, Francisco; Quintana, Yamilet; Rodríguez, José M.

Date of publication: Agust, 2018.

Link: https://link.springer.com/article/10.1007/s13373-017-0104-y

Summary: Weighted Sobolev spaces play a main role in the study of Sobolev orthogonal polynomials. The aim of this paper is to prove several important properties of weighted Sobolev spaces: separability, reflexivity, uniform convexity, duality and Markov-type inequalities.

On bivariate classical orthogonal polynomials

Title: "On bivariate classical orthogonal polynomials"

Authors: Marcellán, Francisco; Marriaga, Misael; Pérez, Teresa E.; Pinar, Miguel A.

Date of publication: May, 2018.

Link: https://www.sciencedirect.com/science/article/abs/pii/S0096300317309074

Summary: We deduce new characterizations of bivariate classical orthogonal polynomials associated with a quasi-definite moment functional, and we revise old properties for these polynomials. More precisely, new characterizations of classical bivariate orthogonal polynomials satisfying a diagonal Pearson-type equation are proved: they are solutions of two separate partial differential equations one for every partial derivative, their partial derivatives are again orthogonal, and every vector polynomial can be expressed in terms of its partial derivatives by means of a linear relation involving only three terms of consecutive total degree. Moreover, we study general solutions of the matrix

second order partial differential equation satisfied by classical orthogonal polynomials, and we deduce the explicit expressions for the matrix coefficients of the structure relation. Finally, some illustrative examples are given.

Amenability of coarse spaces and K-algebras

Title: "Amenability of coarse spaces and K-algebras"

Authors: Ara, Pere; Li, Kang; Lledo, Fernando; Wu, Jianchao.

Source: *Mathematical sciences*. 8 - 2, pp. 257 - 306. World Scientific Publ Co Pte Ltd. ISSN 1664-3607, ISSN 1664-3615.

Date of publication: Agust, 2018.

Summary: In this article we analyze the notions of amenability and paradoxical decomposition from an algebraic perspective. We consider this dichotomy for locally finite extended metric spaces and for general algebras over fields. In the context of algebras we also study the relation of amenability with proper infiniteness. We apply our general analysis to two important classes of algebras: the unital Leavitt path algebras and the translation algebras on locally finite extended metric spaces. In particular, we show that the amenability of a metric space is equivalent to the algebraic amenability of the corresponding translation algebra.

Ultimate data hiding in quantum mechanics and beyond

Title: "Ultimate data hiding in quantum mechanics and beyond"

Authors: Lami, Ludovico; Palazuelos, Carlos; Winter, Andreas.

Source: *Communications in mathematical physics*. 361 - 2, pp. 661 - 708. SPpringer. ISSN 0010-3616, ISSN 1432-0916.

Date of publication: July, 2018.

Link: https://link.springer.com/content/pdf/10.1007/s00220-018-3154-4.pdf

Summary: The phenomenon of data hiding, i.e. the existence of pairs of states of a bipartite system that are perfectly distinguishable via general entangled measurements yet almost indistinguishable under LOCC, is a distinctive signature of non-classicality. The relevant figure of merit is the maximal ratio (called data hiding ratio) between the distinguishability norms associated with the two sets of measurements we are comparing, typically all measurements vs LOCC protocols. For a bipartite $n \times n$ quantum system, it is known that the data hiding ratio scales as n, i.e. the square root of the real dimension of the local state space of density matrices. We show that for bipartite $nA \times nB$ systems the maximum data hiding ratio against LOCC protocols is (min {nA, nB}). This scaling is better than the previously obtained upper bounds and moreover our intuitive argument yields constants close to optimal. In this paper, we investigate data hiding in the more general context of general probabilistic theories (GPTs), an axiomatic framework for physical theories encompassing only the most basic requirements about the predictive power of the theory. The main result of the paper is the determination of the maximal data hiding ratio obtainable in an arbitrary GPT, which is shown to scale linearly in the minimum of the local dimensions. We exhibit an explicit model achieving this bound up to additive constants, finding that the quantum mechanical data hiding ratio is only of the order of the square root of the maximal one. Our proof rests crucially on an unexpected link between data hiding and the theory of projective and injective tensor products of Banach spaces. Finally, we develop a body of techniques to compute data hiding ratios for a variety of restricted classes of GPTs that support further symmetries.

Superadditivity of quantum relative entropy for general states

Title: "Superadditivity of quantum relative entropy for general states"

Authors: Capel, Ángela; Lucia, Angelo; Pérez-García, David.

Source: *IEEE Transactions on information theory*. 64 - 7, pp. 4758 - 4765. IEEE-INST Electrical Electronics Engineers Inc. ISSN 0018-9448, ISSN 1557-9654.

Date of publication: July, 2018.

Link: https://ieeexplore.ieee.org/abstract/document/8105839

Summary: The property of superadditivity of the quantum relative entropy states that, in a bipartite system HAB= HA$\otimes$ HB, for every density operator ρAB, one has D(ρAB||σA$\otimes$ σB)$\geq$ D(ρA||σA) + D(ρB||σB). In this paper, we provide an extension of this inequality for arbitrary density operators σAB. More specifically, we prove that α(σAB)· D(ρAB||σAB)$\geq$D(ρA||σA)+ D(ρB||σB) holds for all bipartite states ρAB and σAB, where α(σAB) = 1 + 2||σA-1/2$\otimes$ σABσA-1/2$\otimes$ σB-1/2- ||AB||∞.

On sets free of sumsets with summands of prescribed size

Title: "On sets free of sumsets with summands of prescribed size"

Authors: Cilleruelo, Javier; Tesoro, Rafael.

Source: *Combinatorica*. 38 - 3, pp. 511 - 546. Springer Heidelberg. ISSN 0209-9683, ISSN 1439-6912.

Date of publication: June, 2018.

Link: https://link.springer.com/article/10.1007/s00493-016-3444-4

Summary: We study extremal problems about sets of integers that do not contain sumsets with summands of prescribed size. We analyse both finite sets and infinite sequences. We also study the connections of these problems with extremal problems of graphs and hypergraphs.

On the geometry of graphs associated to infinite-type surfaces

Title: "On the geometry of graphs associated to infinite-type surfaces"

Authors: Aramayona, Javier; Valdez, Ferrán.

Source: *Mathematische zeitschrift*. 289 - 1-2, pp. 309 - 322. Springer Heidelberg. ISSN 0025-5874, ISSN 1432-1823.

Date of publication: June, 2018.

Link: https://link.springer.com/article/10.1007/s00209-017-1952-6

Summary: Consider a connected orientable surface S of infinite topological type, i.e. with infinitely-generated fundamental group. Our main purpose is to give a description of the geometric structure of an arbitrary subgraph of the arc graph of S, subject to some rather general conditions. As special cases, we recover results of Bavard (Geom Topol 20, 2016) and Aramayona–Fossas–Parlier (Arc and curve graphs for infinite-type surfaces. Preprint, 2015). In the second part of the paper, we obtain a number of results on the geometry of connected, Mod(S)-invariant subgraphs of the curve graph of S, in the case when the space of ends of S is homeomorphic to a Cantor set.

Focal radius, rigidity, and lower curvature bounds

Title: "Focal radius, rigidity, and lower curvature bounds"

Authors: Guijarro, Luis; Wilhelm, Frederick.

Source: Proceedings of the London Mathematical Society. 116, pp. 1519 - 1552. WILEY. ISSN 0024-6115, ISSN 1460-244X.

Date of publication: June, 2018.

Link: https://londmathsoc.onlinelibrary.wiley.com/doi/full/10.1112/plms.12113

Summary: We prove a new comparison lemma for Jacobi fields that exploits Wilking's transverse Jacobi equation. In contrast to standard Riccati and Jacobi comparison theorems, there are situations when our technique can be applied after the first conjugate point.

Using it, we show that the focal radius of any submanifold N of positive dimension in a manifold M with sectional curvature greater than or equal to 1 does not exceed π/2. In the case of equality, we show that N is totally geodesic in M and the universal cover of M is isometric to a sphere or a projective space with their standard metrics, provided that N is closed.

Our results also hold for k th intermediate Ricci curvature, provided that the submanifold has dimension $\geqslant k$. Thus, in a manifold with Ricci curvature $\geqslant n-1$, all hypersurfaces have focal radius $\leqslant \pi/2$, and space forms are the only such manifolds where equality can occur, if the submanifold is closed.

Example 4.38 and Remark 5.4 show that our results cannot be proven using standard Riccati or Jacobi comparison techniques.

Hole probability for zeroes of Gaussian Taylor series with finite radii of convergence

Title: "Hole probability for zeroes of Gaussian Taylor series with finite radii of convergence"

Authors: Buckley, Jeremiah; Nishry, Alon; Peled, Ron; Sodin, Mikhail.

Source: *Probability theory and related fields*. 171 - 1-2, pp. 377 - 430. Springer Heidelberg. ISSN 0178-8051, ISSN 1432-2064.

Date of publication: June, 2018.

Link: https://link.springer.com/article/10.1007/s00440-017-0782-0

Summary: We study a family of random Taylor series with radius of convergence almost surely 1 and independent, identically distributed complex Gaussian coefficients; these Taylor series are distinguished by the invariance of their zero sets with respect to isometries of the unit disk. We find reasonably tight upper and lower bounds on the probability that F does not vanish in the disk {|z|⩽r} as r↑1. Our bounds take different forms according to whether the non-random coefficients (an) grow, decay or remain of the same order. The results apply more generally to a class of Gaussian Taylor series whose coefficients (an) display power-law behavior.

Limited range multilinear extrapolation with applications to the bilinear Hilbert transform

Title: "Limited range multilinear extrapolation with applications to the bilinear Hilbert transform"

Authors: Cruz-Uribe, David; Martell, José María.

Source: *mathematische annalen*. 371 - 1-2, pp. 615 - 653. Springer Heidelberg. ISSN 0025-5831, ISSN 1432-1807.

Date of publication: June, 2018.

Link: https://link.springer.com/article/10.1007/s00208-018-1640-9

Summary: We prove a limited range, off-diagonal extrapolation theorem that generalizes a number of results in the theory of Rubio de Francia extrapolation, and use this to prove a limited range, multilinear extrapolation theorem. We give two applications of this result to the bilinear Hilbert transform. First, we give sufficient conditions on a pair of weights w1, w2 for the bilinear Hilbert transform to satisfy weighted norm inequalities of the form.

$BH: L^{p1}(w_1^{p1}) \times L^{p2}(w_2^{p2}) \longrightarrow L^p(w^p), BH: L^{p1}(w_1^{p1}) \times L^{p2}(w_2^{p2}) \longrightarrow L^p(w^p),$

where w=w1.w2 and 1/p=1/p1+1/p2 < 3/2. This improves the recent results of Culiuc et al. by increasing the families of weights for which this inequality holds and by pushing the lower bound on p from 1 down to 2/3, the critical index from the unweighted theory of the bilinear Hilbert transform. Second, as an easy consequence of our method we obtain that the bilinear Hilbert transform satisfies some vector-valued inequalities with Muckenhoupt weights. This reproves and generalizes some of the vector-valued estimates obtained by Benea and Muscalu in the unweighted case. We also generalize recent results of Carando, et al. on Marcinkiewicz-Zygmund estimates for multilinear Calderón-Zygmund operators.

Explicit formulas for C^(1,1) and C^(1,w)conv extensions of 1-jets in Hilbert and superreflexive spaces

Title: "Explicit formulas for C^(1,1) and C^(1,w)conv extensions of 1-jets in Hilbert and superreflexive spaces"

Authors: Azagra, Daniel; Le Gruyer, Erwan; Mudarra, Carlos.

Source: *journal of functional analysis*. 274 - 10, pp. 3003 - 3032. Academic Press Inc Elsevier Science. ISSN 0022-1236, ISSN 1096-0783

Date of publication: May, 2018.

Link: http://www.mat.ucm.es/~dazagrar/articulos/Formulae-ForC11Extension171204.pdf

Summary: Given a Hilbert space, ω a modulus of continuity, E an arbitrary subset of X, and functions f:E→R, G:E→X, we provide necessary and sufficient conditions for the jet (f,G) to admit an extension (F,∇F) with F: X→R convex and of class C1, ω(X), by means of a simple explicit formula. As a consequence of this result, if ω is linear, we show that a variant of this formula provides explicit C^(1,1) extensions of general (not necessarily convex) 1-jets satisfying the usual Whitney extension condition, with best possible Lipschitz constants of the gradients of the extensions. Finally, if X is a superreflexive Banach space, we establish similar results for the classes C^(1,w)conv

Characterization for stability in planar conductivities

Title: "Characterization for stability in planar conductivities"

Authors: Faraco, Daniel; Prats, Martí.

Source: Journal of differential equations. 264 - 9, pp. 5659 - 5712. ACADEMIC PRESS INC ELSEVIER SCIENCE. ISSN 0022-0396, ISSN 1090-2732

Date of publication: May, 2018.

Link: https://www.sciencedirect.com/science/article/pii/S0022039618300159

Summary: We find a complete characterization for sets of uniformly strongly elliptic and isotropic conductivities with stable recovery in the norm when the data of the Calderón Inverse Conductivity Problem is obtained in the boundary of a disk and the conductivities are constant in a neighborhood of its boundary. To obtain this result, we present minimal a priori assumptions which turn out to be sufficient for sets of conductivities to have stable recovery in a bounded and rough domain. The condition is presented in terms of the integral moduli of continuity of the coefficients involved and their ellipticity bound as conjectured by Alessandrini in his 2007 paper, giving explicit quantitative control for every pair of conductivities.

Stability results, almost global generalized Beltrami fields and applications to vortex structures in the Euler equations

Title: "Stability results, almost global generalized Beltrami fields and applications to vortex structures in the Euler equations"

Authors: Enciso, Alberto; Poyato, David; Soler, Juan.

Summary: Strong Beltrami fields, that is, vector fields in three dimensions whose curl is the product of the field itself by a constant factor, have long played a key role in fluid mechanics and magnetohydrodynamics. In particular, they are the kind of stationary solutions of the Euler equations where one has been able to show the existence of vortex structures (vortex tubes and vortex lines) of arbitrarily complicated topology. On the contrary, there are very few results about the existence of generalized Beltrami fields, that is, divergence-free fields whose curl is the field times a non-constant function. In fact, generalized Beltrami fields (which are also stationary solutions to the Euler equations) have been recently shown to be rare, in the sense that for "most" proportionality factors there are no nontrivial Beltrami fields of high enough regularity, not even locally. Our objective in this work is to show that, nevertheless, there are "many" Beltrami fields with non-constant factor, even realizing arbitrarily complicated vortex structures. This fact is relevant in the study of turbulent configurations. The core results are an "almost global" stability theorem for strong Beltrami fields, which ensures that a global strong Beltrami field with suitable decay at infinity can be perturbed to get "many" Beltrami fields with non-constant factor of arbitrarily high regularity and defined in the exterior of an arbitrarily small ball, and a "local" stability theorem for generalized Beltrami fields, which is an analogous perturbative result which is valid for any kind of Beltrami field (not just with a constant factor) but only applies to small enough domains. The proof relies on an iterative scheme of Grad–Rubin type. For this purpose, we study the Neumann problem for the inhomogeneous Beltrami equation in exterior domains via a boundary integral equation method and we obtain Hölder estimates, a sharp decay at infinity and some compactness properties for these sequences of approximate solutions. Some of the parts of the proof are of independent interest.

Finite 2-groups with odd number of conjugacy classes

Title: "Finite 2-groups with odd number of conjugacy classes"

Authors: Jaikin-Zapirain, Andrei; Tent, Joan.

Summary: In this paper we consider finite 2-groups with odd number of real conjugacy classes. On one hand we show that if k is an odd natural numberless than 24, then there are only finitely many finite 2-groups with exactly k real conjugacy classes. On the other hand we construct infinitely many finite 2-groups with exactly 25 real conjugacy classes. Both resuls are proven using pro-p techniques, and, in particular, we use the Kneser classification of semi-simple p-adic algebraic groups.

Adversarial issues in reliability

Title: "Adversarial issues in reliability"

Authors: Ríos Insua, David; Ruggeri, Fabrizio; Soyer, Refik; Rasines, Daniel G.

Summary: Many reliability problems involve two or more agents with conflicting interests whose decisions affect the performance of the system at hand. Examples of such problems relevant in management practice abound and include acceptance sampling, life testing, software testing, optimal maintenance, reliability demonstration, warranties and insurance. Most earlier attempts in such problems have focused on game theoretic approaches based on Nash equilibria and related concepts. However, these require strong common knowledge assumptions which do not frequently hold in practice. We provide an alternative framework based on adversarial risk analysis to deal with such problems which avoids the strong common knowledge assumptions of game theory. We illustrate the framework through acceptance sampling and life testing problems.

Global well-posedness of critical surface quasigeostrophic equation on the sphere

Title: "Global well-posedness of critical surface quasigeostrophic equation on the sphere"

Authors: Alonso-Orán, Diego; Córdoba, Antonio; Martínez, Ángel D.

Summary: In this paper we prove global well-posedness of the critical surface quasigeostrophic equation on the two dimensional sphere, building on some earlier work of the authors. The proof relies on an improving of the previously known pointwise inequality for fractional Laplacians as in the work of Constantin and Vicol for the Euclidean setting.

Continuity of weak solutions of the critical surface quasi-geostrophic equation on S-2

Title: "Continuity of weak solutions of the critical surface quasi-geostrophic equation on S-2"

Authors: Alonso-Orán, Diego; Córdoba, Antonio; Martínez, Ángel D.

Summary: In this paper we provide regularity results for active scalars that are weak solutions of drift-diffusion equations in general surfaces. This includes models of anisotropic non-homogeneous media and the physically motivated case of the two-dimensional sphere. Our finest result deals with the critical surface quasigeostrophic equation on the round sphere.

Integral representation for fractional Laplace-Beltrami operators

Title: "Integral representation for fractional Laplace-Beltrami operators"

Authors: Alonso-Orán, Diego; Córdoba, Antonio; Martínez, Ángel D.

Date of publication: April, 2018.

Link: https://www.sciencedirect.com/science/article/pii/S0001870818300318

Summary: In this paper we provide an integral representation of the fractional Laplace–Beltrami operator for general riemannian manifolds which has several interesting applications. We give two different proofs, in two different scenarios, of essentially the same result. The first deals with compact manifolds with or without boundary, while the second approach treats the case of riemannian manifolds without boundary whose Ricci curvature is uniformly bounded below.

Riemann-Roch for homotopy invariant K-theory and Gysin morphisms

Title: "Riemann-Roch for homotopy invariant K-theory and Gysin morphisms"

Author: Navarro, Alberto.

Date of publication: April, 2018.

Link: https://www.sciencedirect.com/science/article/pii/S0001870818300094

Summary: We prove the Riemann–Roch theorem for homotopy invariant K-theory and projective local complete intersection morphisms between finite dimensional noetherian schemes, without smoothness assumptions. We also prove a new Riemann–Roch theorem for the relative cohomology of a morphism.

In order to do so, we construct and characterize new Gysin morphisms for regular immersions between cohomologies represented by spectra (examples include homotopy invariant K-theory, motivic cohomology, their arithmetic counterparts, real absolute Hodge and Deligne–Beilinson cohomology, rigid syntomic cohomology, mixed Weil cohomologies) and we use this construction to prove a motivic version of the Riemann–Roch.

Sobolev homeomorphisms with gradients of low rank via laminate

Title: "Sobolev homeomorphisms with gradients of low rank via laminate"

Authors: Faraco, Daniel; Mora-Corral, Carlos; Oliva, Marcos.

Date of publication: April, 2018.

Link: https://www.degruyter.com/view/j/acv.2018.11.issue-2/acv-2016-0009/acv-2016-0009.xml

Summary: Let $\Omega \subset Rn$ be a bounded open set. Given $2 \leq m \leq n$, we construct a convex function $u: \Omega \rightarrow R$ whose gradient $f = \nabla u$ is a Hölder continuous homeomorphism, f is the identity on $\partial\Omega$, the derivative Df has rank m−1 a.e. in Ω and Df is in the weak Lm space Lm,w. The proof is based on convex integration and staircase laminates.

Higgs bundles for real groups and the Hitchin-Kostant-Rallis section

Title: "Higgs bundles for real groups and the Hitchin-Kostant-Rallis section"

Authors: García-Prada, Oscar; Peón-Nieto, Ana; Ramanan, S.

Date of publication: April, 2018.

Link: https://www.ams.org/journals/tran/2018-370-04/S0002-9947-2017-07363-3/home.html

Summary: We consider the moduli space of polystable L-twisted G-Higgs bundles over a compact Riemann surface X, where G is a real reductive Lie group and L is a holomorphic line bundle over X. Evaluating the Higgs field on a basis of the ring of polynomial invariants of the isotropy representation defines the Hitchin map. This is a map to an affine space whose dimension is determined by L and the degrees of the polynomials in the basis. In this paper, we construct a section of this map and identify the connected components of the moduli space containing the image. This section factors through the moduli space for G-split, a split real subgroup of G. Our results generalize those by Hitchin, who considered the case when L is the canonical line bundle of X and G is complex. In this case, the image of the section is related to the Hitchin-Teichmüller components of the moduli space of representations of the fundamental group of X in G-split, a split real form of G. The construction involves the notion of a maximal split subgroup of a real reductive Lie group and builds on results by Kostant and Rallis.

Universality in the nonlinear leveling of capillary films

Title: "Universality in the nonlinear leveling of capillary films"

Authors: Zheng, Zhong; Fontelos, Marco A.; Shin, Sangwoo; Stone, Howard A.

Date of publication: March, 2018.

Link: https://journals.aps.org/prfluids/abstract/10.1103/PhysRevFluids.3.032001

Summary: Many material science, coating, and manufacturing problems involve liquid films where defects that span the film thickness must be removed. Here, we study the surface-tension-driven leveling dynamics of a thin viscous film following closure of an initial hole. The dynamics of the film shape is described by a nonlinear evolution equation, for which we obtain a self-similar solution. The analytical results are verified using time-dependent numerical and experimental results for the profile shapes and the minimum film thickness at the center. The universal behavior we identify can be useful for characterizing the time evolution of the leveling process and estimating material properties from experiments.

Memory effects can make the transmission capability of a communication channel uncomputable

Title: "Memory effects can make the transmission capability of a communication channel uncomputable"

Authors: Elkouss, David; Pérez-García, David.

Date of publication: March, 2018.

Link: https://www.nature.com/articles/s41467-018-03428-0

Summary: Most communication channels are subjected to noise. One of the goals of information theory is to add redundancy in the transmission of information so that the information is transmitted reliably and the amount of information transmitted through the channel is as large as possible. The maximum rate at which reliable transmission is possible is called the capacity. If the channel does not keep memory of its past, the capacity is given by a simple optimization problem and can be efficiently computed. The situation of channels with memory is less clear. Here we show that for channels with memory the capacity cannot be computed to within

precision 1/5. Our result holds even if we consider one of the simplest families of such channels—information-stable finite state machine channels—restrict the input and output of the channel to 4 and 1 bit respectively and allow 6 bits of memory.

Lagrangian coherent structure assisted path planning for transoceanic autonomous underwater vehicle missions

Title: "Lagrangian coherent structure assisted path planning for transoceanic autonomous underwater vehicle missions"

Authors: Ramos, Antonio G.; García-Garrido, Víctor J.; Mancho, Ana M.; Wiggins, Stephen; Coca, Alberto J.; Glenn, Stevens; Schofield, Oscar; Kohut, Josh; Aragón, Dave; Kerfoot, John; Haskins, Tina; Miles, Travis; Haldeman, Clinton; Strandskov, Nilsen; Allsup, Ben; Jones, Clayton; Shapiro, Justin.

Source: *Scientific reports*. 8, Nature Publishing Group. ISSN 2045-2322.

Date of publication: March, 2018.

Link: https://www.nature.com/articles/s41598-018-23028-8

Summary: Transoceanic Gliders are Autonomous Underwater Vehicles (AUVs) for which there is a developing and expanding range of applications in open-seas research, technology and underwater clean transport. Mature glider autonomy, operating depth (0–1000 meters) and low energy consumption without a CO_2 footprint enable evolutionary access across ocean basins. Pursuant to the first successful transatlantic glider crossing in December 2009, the Challenger Mission has opened the door to long-term, long-distance routine transoceanic AUV missions. These vehicles, which glide through the water column between 0 and 1000 meters depth, are highly sensitive to the ocean current field. Consequently, it is essential to exploit the complex space-time structure of the ocean current field in order to plan a path that optimizes scientific payoff and navigation efficiency. This letter demonstrates the capability of dynamical system theory for achieving this goal by realizing the real-time navigation strategy for the transoceanic AUV named Silbo, which is a Slocum deep-glider (0–1000 m), that crossed the North Atlantic from April 2016 to March 2017. Path planning in real time based on this approach has facilitated an impressive speed up of the AUV to unprecedented velocities resulting in major battery savings on the mission, offering the potential for routine transoceanic long duration missions.

Healing capillary films

Title: "Healing capillary films"

Authors: Zheng, Zhong; Fontelos, Marco A.; Shin, Sangwoo; Dallaston, Michael C.; Tseluiko, Dmitri; Kalliadasis, Serafim; Stone, Howard A.

Source: *Journal of fluid mechanics*. 838, pp. 404 - 434. Cambridge Univ Press. ISSN 0022-1120, ISSN 1469-7645

Date of publication: March, 2018.

Link: https://www.cambridge.org/core/journals/journal-of-fluid-mechanics/article/healing-capillary-films/6922F-8969719504DAA35A35EAEF99A37

Summary: Consider the dynamics of a healing film driven by surface tension, that is, the inward spreading process of a liquid film to fill a hole. The film is modelled using the lubrication (or thin-film) approximation, which results in a fourth-order nonlinear partial differential equation. We obtain a self-similar solution describing the early-time relaxation of an initial step-function condition and a family of self-similar solutions governing the finite-time healing. The similarity exponent of this family of solutions is not determined purely from scaling arguments; instead, the scaling exponent is a function of the finite thickness of the prewetting film, which we determine numerically. Thus, the solutions that govern

the finite-time healing are self-similar solutions of the second kind. Laboratory experiments and time-dependent computations of the partial differential equation are also performed. We compare the self-similar profiles and exponents, obtained by matching the estimated prewetting film thickness, with both measurements in experiments and time-dependent computations near the healing time, and we observe good agreement in each case.

Thermal rupture of a free liquid sheet

Title: "Thermal rupture of a free liquid sheet"

Authors: Kitavtsev, Georgy; Fontelos, Marco Antonio; Eggers, Jens.

Source: *Journal of fluid mechanics*. 840, pp. 555 - 578. Cambridge Univ Press. ISSN 0022-1120, ISSN 1469-7645

Date of publication: February, 2018.

Link: https://www.cambridge.org/core/journals/journal-of-fluid-mechanics/article/thermal-rupture-of-a-free-liquid-sheet/E5CC71C88E3A03FB993B5183DDA259DA

Summary: We consider a free liquid sheet, taking into account the dependence of surface tension on the temperature or concentration of some pollutant. The sheet dynamics are described within a long-wavelength description. In the presence of viscosity, local thinning of the sheet is driven by a strong temperature gradient across the pinch region, resembling a shock. As a result, for long times the sheet thins exponentially, leading to breakup. We describe the quasi-one-dimensional thickness, velocity and temperature profiles in the pinch region in terms of similarity solutions, which possess a universal structure. Our analytical description agrees quantitatively with numerical simulations.

On the sharpness of the Russmann estimates

Title: "On the sharpness of the Russmann estimates"

Authors: Figueras, Jordi-Lluis; Haro, Álex; Luque, Alejandro.

Source: *Communications in nonlinear science and numerical simulation*. 55, pp. 42 - 55. Elsevier Science Bv, ISSN 1007-5704, ISSN 1878-7274

Date of publication: February, 2018.

Link: https://www.sciencedirect.com/science/article/pii/S1007570417302277

Summary: Estimating the norm of the solution of a linear difference equation plays a fundamental role in KAM theory. Optimal (in certain sense) estimates for the solution of this equation were provided by Rüssmann in the mid 70's. The aim of this paper is to compare the sharpness of these classical estimates with more specific estimates obtained with the help of the computer. We perform several experiments to quantify the improvement obtained when using computer assisted estimates. By comparing these estimates with the actual norm of the solution, we can analyze the different sources of overestimation, thus encouraging future improvements.

v-SVM solutions of constrained Lasso and Elastic net

Title: "v-SVM solutions of constrained Lasso and Elastic net"

Authors: Torres-Barrán, Alberto; Alaiz, Carlos M.; Dorronsoro, José R.

Source: *Neurocomputing*. 275, pp. 1921 - 1931. Elsevier Science Bv. ISSN 0925-2312, ISSN 1872-8286.

Date of publication: January, 2018.

Link: https://www.sciencedirect.com/science/article/pii/S0925231217316806

Summary: Many important linear sparse models have at its core the Lasso problem, for which the GLMNet algorithm is often considered as the current state of the art. Recently M. Jaggi has observed that Constrained Lasso (CL) can be reduced to an SVM-like problem, for which the LIBSVM library provides very efficient algorithms. This suggests that it could also be used advantageously to solve CL. In this work we will refine Jaggi's arguments to reduce CL as well as constrained Elastic Net to a Nearest Point Problem, which in turn can be rewritten as an appropriate ν-SVM problem solvable by LIBSVM. We will also show experimentally that the well-known LIBSVM library results in a faster convergence than GLMNet for small problems and also, if properly adapted, for larger ones. Screening is another ingredient to speed up solving Lasso. Shrinking can be seen as the simpler alternative of SVM to screening and we will discuss how it also may in some cases reduce the cost of an SVM-based CL solution.

Late-time behaviour of the Einstein-Boltzmann system with a positive cosmological constant

Title: "Late-time behaviour of the Einstein-Boltzmann system with a positive cosmological constant"

Authors: Lee, Ho; Nungesser, Ernesto.

Summary: In this paper we study the Einstein–Boltzmann system for Israel particles with a positive cosmological constant. We consider spatially homogeneous solutions of all Bianchi types except type IX and obtain future global existence and the asymptotic behaviour of solutions to the Einstein–Boltzmann system. The result shows that the solutions converge to the de Sitter solution at late times.

Discrete self-similarity in interfacial hydrodynamics and the formation of iterated structures

Title: "Discrete self-similarity in interfacial hydrodynamics and the formation of iterated structures"

Authors: Dallaston, M.A.; Fontelos, M.A.; Tseluiko, D.; Kalliadasis, S.

Summary: The formation of iterated structures, such as satellite and subsatellite drops, filaments, and bubbles, is a common feature in interfacial hydrodynamics. Here we undertake a computational and theoretical study of their origin in the case of thin films of viscous fluids that are destabilized by long-range molecular or other forces. We demonstrate that iterated structures appear as a consequence of discrete self-similarity, where certain patterns repeat themselves, subject to rescaling, periodically in a logarithmic time scale. The result is an infinite sequence of ridges and filaments with similarity properties. The character of these discretely self-similar solutions as the result of a Hopf bifurcation from ordinarily self-similar solutions is also described.

Size-driven quantum phase transitions

Title: "Size-driven quantum phase transitions"

Authors: Bausch, Johannes; Cubitt, Toby S.; Lucia, Angelo; Perez-García, David; Wolf, Michael M.

Summary: Can the properties of the thermodynamic limit of a many-body quantum system be extrapolated by analyzing a sequence of finite-size cases? We present models for which such an approach gives completely misleading results: translationally invariant, local Hamiltonians on a square lattice with open boundary conditions and constant spectral gap, which have a classical product ground state for all system sizes smaller than a particular threshold size, but a ground state with topological degeneracy for all system sizes larger than this threshold. Starting from a minimal case with spins of dimension 6 and threshold lattice size 15×15, we show that the latter grows faster than any computable function with increasing local spin dimension. The resulting effect may be viewed as a unique type of quantum phase transition that is driven by the size of the system rather than by an external field or coupling strength. We prove that the construction is thermally robust, showing that these effects are in principle accessible to experimental observation.

Holomorphic maps between moduli spaces

Title: "Holomorphic maps between moduli spaces"

Authors: Antonakoudis, Stergios; Aramayona, Javier; Souto, Juan.

Summary: We prove that every non-constant holomorphic map $M_{g,p} \to M_{g',p'}$ between moduli spaces of Riemann surfaces is a forgetful map, provided that $g \geq 6$ and $g' \leq 2g-2$.

A numerical algorithm for c-2-splines on symmetric spaces

Title: "A numerical algorithm for c-2-splines on symmetric spaces"

Authors: Bogfjellmo, Geir; Modin, Klas; Verdier, Olivier.

Summary: Cubic spline interpolation on Euclidean space is a standard topic in numerical analysis, with countless applications in science and technology. In several emerging fields, for example, computer vision and quantum control, there is a growing need for spline interpolation on curved, non-Euclidean space. The generalization of cubic splines to manifolds is not self-evident, with several distinct approaches. One possibility is to mimic the acceleration minimizing property, which leads to *Riemannian cubics*. This, however, requires the solution of a coupled set of nonlinear boundary value problems that cannot be integrated explicitly, even if formulae for geodesics are available. Another possibility is to mimic De Casteljau's algorithm, which leads to *generalized Bézier curves*. To construct C^2-splines from such curves is a complicated nonlinear problem, until now lacking numerical methods. Here we provide an iterative algorithm for C^2-splines on Riemannian symmetric spaces, and we prove convergence of linear order. In terms of numerical tractability and computational efficiency, the new method surpasses those based on Riemannian cubics. Each iteration is parallel and thus suitable for multicore implementation. We demonstrate the algorithm for three geometries of interest: the n-sphere, complex projective space, and the real Grassmannian.

Dislocations of arbitrary topology in Coulomb eigenfunctions

Title: "Dislocations of arbitrary topology in Coulomb eigenfunctions"

Authors: Enciso, Alberto; Hartley, David; Peralta-Salas, Daniel.

Source: *Revista Matematica Iberoamericana*. 34 - 3, pp. 1361 - 1371. European Mathematical Soc, ISSN 0213-2230

Date of publication: January, 2018.

Link: https://www.ems-ph.org/journals/show_abstract.php?issn=0213-2230&vol=34&iss=3&rank=16

Summary: For any finite link L in R3 we prove the existence of a complex-valued eigenfunction of the Coulomb Hamiltonian such that its nodal set contains a union of connected components diffeomorphic to L. This problem goes back to Berry, who constructed such eigenfunctions in the case where L is the trefoil knot or the Hopf link and asked the question about the general result.

C-0-semigroups of 2-isometries and Dirichlet spaces

Title: "C-0-semigroups of 2-isometries and Dirichlet spaces"

Authors: Gallardo-Gutiérrez, Eva A.; Partington, Jonathan R.

Source: *Revista Matematica Iberoamericana*. 34 - 3, pp. 1415 - 1425. European Mathematical Soc, ISSN 0213-2230

Date of publication: January, 2018.

Link: https://www.ems-ph.org/journals/show_abstract.php?issn=0213-2230&vol=34&iss=3&rank=20

Summary: In the context of a theorem of Richter, we establish a similarity between C0-semigroups of analytic 2-isometries $\{T(t)\}t\geq0$ acting on a Hilbert space H and the multiplication operator semigroup $\{M\phi t\}t\geq0$ induced by $\phi t(s)=\exp(-st)$ for s in the right-half plane C+ acting boundedly on weighted Dirichlet spaces on C+. As a consequence, we derive a connection with the right shift semigroup $\{St\}t\geq0$ given by $Stf(x)=\{0f(x-t)$ if $0\leq x\leq t$, if $x>t$, acting on a weighted Lebesgue space on the half line R+ and address some applications regarding the study of the invariant subspaces\linebreak of C0-semigroups of analytic 2-isometries.

Long term dynamics for the restricted N-Body problem with mean motion resonances and crossing singularities

Title: "Long term dynamics for the restricted N-Body problem with mean motion resonances and crossing singularities "

Authors: Maro, Stefano; Gronchi, Giovanni F.

Source: *Siam Journal on Applied Dynamical Systems*. 17 - 2, pp. 1786 - 1815. Siam Publications. ISSN 1536-0040.

Date of publication: January, 2018.

Link: https://epubs.siam.org/doi/abs/10.1137/17M1155703?-journalCode=sjaday

Summary: We consider the long term dynamics of the restricted N-body problem, modeling in a statistical sense the motion of an asteroid in the gravitational field of the Sun and the solar system planets. We deal with the case of a mean motion resonance with one planet and assume that the osculating trajectory of the asteroid crosses the one of some planet, possibly different from the resonant one, during the evolution. Such crossings produce singularities in the differential equations for the motion of the asteroid, obtained by standard perturbation theory. In this work we prove that the vector field of these equations can be extended to two locally Lipschitz-continuous vector fields on both sides of a set of crossing conditions. This allows us to define generalized solutions, continuous but not differentiable, going beyond these singularities. Moreover, we prove that the long term evolution of the "signed" orbit distance [G. F. Gronchi and G. Tommei, *Discrete Contin. Dyn. Syst. Ser. B*, 7 (2007), pp. 755--778] between the asteroid and the planet is differentiable in a neighborhood of the crossing times. In case of crossings with the resonant planet we recover the known dynamical protection mechanism against collisions. We conclude with a numerical comparison between the long term and the full evolutions in the case of asteroids belonging to the "Alinda" and "Toro" classes [A. Milani et al., *Icarus*, 78 (1989), pp. 212--269]. This work extends the results in [G. F. Gronchi and C. Tardioli, *Discrete Contin. Dyn. Syst. Ser. B*, 18 (2013), pp. 1323--1344] to the relevant case of asteroids in mean motion resonance with a planet.

Renormalisation group for multIple zeta-values

Title: "Renormalisation group for multiple zeta values"

Authors: Ebrahimi-Fard, Kurusch; Manchon, Dominique; Singer, Johannes; Zhao, Janqiang.

Source: *Communications in number theory and physics*. 12 - 1, pp. 75 - 96. Int Press Boston, Inc, ISSN 1931-4523, ISSN 1931-4531

Date of publication: January, 2018.

Link: https://link.springer.com/article/10.1007/s11005-016-0818-x

Summary: We consider a particular one-parameter family of q-analogues of multiple zeta values. The intrinsic q-regularisation permits an extension of these q-multiple zeta values to negative integers. Renormalised multiple zeta values satisfying the quasi-shuffle product are obtained using a Hopf-algebraic Birkhoff factorisation together with minimal subtraction.

On the kato problem and extensions for degenerate elliptic operators

Title: "On the kato problem and extensions for degenerate elliptic operators"

Authors: Cruz-Uribe, David; María Martell, José; Ríos, Cristian.

Source: *Analysis & Pde*. 11 - 3, pp. 609 - 660. Mathematical Science Publ. ISSN 1948-206X.

Date of publication: January, 2018.

Link: https://msp.org/apde/2018/11-3/apde-v11-n3-p03-s.pdf

Summary: We study the Kato problem for divergence form operators whose ellipticity may be degenerate. The study of the Kato conjecture for degenerate elliptic equations was begun by Cruz-Uribe and Ríos (2008, 2012, 2015). In these papers the authors proved that given an operator $Lw=-w-1\mathrm{div}(A\nabla)$, where w is in the Muckenhoupt class A2 and A is a w-degenerate elliptic measure (that is, $A=wB$ with $B(x)$ an $n\times n$ bounded, complex-valued, uniformly elliptic matrix), then Lw satisfies the weighted estimate $\|\|\sqrt{Lwf}\|L^2(w)\approx\|\nabla f\|\|L^2(w)$. In the present paper we solve the L^2-Kato problem for a family of degenerate elliptic operators. We prove that under some additional conditions on the weight w, the following unweighted L^2-Kato estimates hold:

$$\|\|L1/2wf\|L2(Rn)\approx\|\nabla f\|L^2(Rn).$$

This extends the celebrated solution to the Kato conjecture by Auscher, Hofmann, Lacey, McIntosh, and Tchamitchian, allowing the differential operator to have some degree of degeneracy in its ellipticity. For example, we consider the family of operators $L\gamma=-\|x\|\gamma\mathrm{div}(\|x\|-\gamma B(x)\nabla)$, where B is any bounded, complex-valued, uniformly elliptic matrix. We prove that there exists $\epsilon>0$, depending only on dimension and the ellipticity constants, such that

$$\|\|\|L1/2\gamma f\|L2(Rn)\approx\|\nabla f\|L^2(Rn), -\epsilon<\gamma<2nn+2.$$

The case $\gamma=0$ corresponds to the case of uniformly elliptic matrices. Hence, our result gives a range of γ's for which the classical Kato square root proved in Auscher et al. (2002) is an interior point.

Our main results are obtained as a consequence of a rich Calderón–Zygmund theory developed for certain operators naturally associated with Lw. These results, which are of independent interest, establish estimates on Lp(w), and also on Lp(vdw) with v∈A∞(w), for the associated semigroup, its gradient, the functional calculus, the Riesz transform, and vertical square functions. As an application, we solve some unweighted L^2-Dirichlet, regularity and Neumann boundary value problems for degenerate elliptic operators.

On the simplification of singularities by blowing up at equimultiple centers

Title: "On the simplification of singularities by blowing up at equimultiple centers"

Author: Villamayor, Orlando E.

Source: *Indiana University Mathematics Journal*. 67 - 1, pp. 221 - 266. Indiana Univ Math Journal. ISSN 0022-2518, ISSN 1943-5258.

Date of publication: enero de 2018.

Link: http://www.iumj.indiana.edu/oai/2018/67/6263/6263.xml

Noncommutative Riesz transforms – dimension free bounds and Fourier multipliers

Title: "Noncommutative Riesz transforms – dimension free bounds and Fourier multipliers"

Authors: Junge, Marius; Mei, Tao; Parcet, Javier.

Source: *Journal of the European Mathematical Society 20* (2018), 529-595. (JCR 11/310)

Date of publication: January, 2018.

Link: https://www.ems-ph.org/journals/show_Summary.php?issn=1435-9855&vol=20&iss=3&rank=1

Summary: We obtain dimension free estimates for noncommutative Riesz transforms associated to conditionally negative length functions on group von Neumann algebras. This includes Poisson semigroups, beyond Bakry's results in the commutative setting. Our proof is inspired by Pisier's method and a new Khintchine inequality for crossed products. New estimates include Riesz transforms associated to fractional laplacians in Rn (where Meyer's conjecture fails) or to the word length of free groups. Lust-Piquard's work for discrete laplacians on LCA groups is also generalized in several ways. In the context of Fourier multipliers, we will prove that Hörmander–Mikhlin multipliers are Littlewood-Paley averages of our Riesz transforms. This is highly surprising in the Euclidean and (most notably) noncommutative settings. As application we provide new Sobolev/Besov type smoothness conditions. The Sobolev-type condition we give refines the classical one and yields dimension free constants. Our results hold for arbitrary unimodular groups.

A problem of Berry and knotted zeros in the eigenfunctions of the harmonic oscillator

Title: "A problem of Berry and knotted zeros in the eigenfunctions of the harmonic oscillator"

Authors: Enciso, Alberto; Hartley, David; Peralta-Salas, Daniel.

Source: *Journal of the European Mathematical Society 20* (2018) 301-314.

Date of publication: 2018

Link: https://www.ems-ph.org/journals/show_abstract.php?issn=1435-9855&vol=20&iss=2&rank=2

Summary: Se prueba una conjetura de M. Berry (2001) sobre los conjuntos nodales de las autofunciones del oscilador armónico en el espacio Euclídeo.

On Mordell-Weil groups and congruences between derivatives of twisted Hasse-Weil L-functions

Title: "On Mordell-Weil groups and congruences between derivatives of twisted Hasse-Weil L-functions"

Authors: Burns, D.; Macias Castillo, D.; Wuthrich, C.

Source: *Journal fur die reine und angewandte mathematik*, Vol. 734, 187-228, 2018.

Date of publication: January, 2018.

Link: https://www.degruyter.com/view/j/crelle.2018.2018.issue-734/crelle-2014-0153/crelle-2014-0153.xml

Summary: Let A be an abelian variety defined over a body of numbers k, and let F be a finite extension and Galois k. Let p be a prime number. In this article, the authors explicitly calculate the algebraic part of the p-component of the relevant equivariant Tamagawa number under certain not overly prescriptive conditions over A and F. By comparing the result of this calculation with the Gross-Zagier Theorem, they are able to provide the first verification of the p-component of the equivariant Tamagawa number conjecture for an abelian variety in the most demanding case in which the relevant Mordell-Weil group has a strictly positive range, and the relevant extension of bodies is therefore non-abelian of degree divisible by p. More generally, this approach leads them to both the formulation of certain precise families of p-adic conjectural congruences between the values in s=1 of derivatives of the Hasse-Weil L functions associated to the twistings of A, normalized by a product of equivariant regulators and explicit periods, and to explicit predictions about the Galois structure of Tate-Shafarevich groups. In many interesting cases, we obtain theoretical and numerical evidence in favour of these more general predictions.

Simplicial Abel-Jacobi maps and reciprocity laws

Title: "Simplicial Abel-Jacobi maps and reciprocity laws"

Authors: Kerr, Matt; Lewis, James; Lopatto, Patrick; Burgos-Gil, José Ignacio.

Source: *Journal of Algebraic Geometry*. 27 - 1, pp. 121 - 172. Univ Press Inc, ISSN 1056-3911, ISSN 1534-7486.

Date of publication: January, 2018

Link: https://www.ams.org/journals/jag/2018-27-01/S1056-3911-2017-00692-1/

Summary: We describe an explicit morphism of complexes that induces the cycle-class maps from (simplicially described) higher Chow groups to rational Deligne cohomology. The reciprocity laws satisfied by the currents we introduce for this purpose are shown to provide a clarifying perspective on functional equations satisfied by complex-valued di- and trilogarithms.

5. Awards and distinctions

In 2018, Diego Córdoba obtained an Advanced Grant from the European Research Council (ERC), the highest recognition for a senior scientist in Europe. A few months before, this researcher and scientific director of the Severo Ochoa Project attended the International Congress of Mathematicians in Rio de Janeiro to give an invited talk. Among other international recognition given to ICMAT researchers, it is necessary to mention the concession of a "La Caixa" Foundation Postdoctoral Junior Leader grant to Jared Aurentz. In addition, Ana María Mancho was an invited speaker at the 71st annual meeting of the Dynamic Fluids Division (DFD) of the American Physical Society (APS), one of the most important conferences on fluids in the world.

At a national level, Carolina Vallejo, a postdoctoral researcher at the ICMAT, and Álvaro del Pino, a former PhD student at the Institute, were both recognized in the 2018 RSME and BBVA Foundation Vicent Caselles awards, while Javier Gómez, a former PhD student and collaborator at the ICMAT, received the "Antonio Valle" SeMA Prize for young researchers in applied mathematics. Likewise, David Pérez was appointed Associate Academic of the Royal Academy of Sciences, and Fernando Chamizo was awarded the first prize at the fourth edition of the CEI UAM+CSIC Scientific Essay competition.

The best young national mathematicians

Vicent Caselles

The *Real Sociedad Matemática Española* (RSME – Royal Spanish Mathematical Society) and the BBVA Foundation awarded their 2018 Vicent Caselles Prizes for mathematical research for researchers under 30 years of age who are in the first stages of their professional careers. Among the prize winners was Carolina Vallejo, a postdoctoral researcher at the ICMAT, whose work is based on the representation theory of finite groups; specifically, the study of the relations between the characters of a group and its subgroups. A further award winner was Álvaro del Pino, currently a postdoctoral researcher at the University of Utrecht (Holland), and former PhD student of differential topology at the ICMAT under the supervision of Francisco Presas (ICMAT-CSIC).

A new ERC for the ICMAT

Diego Córdoba

In 2018, Diego Córdoba was the only Spaniard among the nine researchers chosen in the field of mathematics for the European Research Council Advanced Grant Programme. When this programme was launched in 2007, this Spanish researcher was recognized with an ERC Starting Grant, awarded to researchers in the first stages of their careers. Now, thanks to this project, which carries an endowment of 1.8 million euros, Córdoba will pursue the same line of research that has gained him international recognition, that is, the study of the existence of singularities in the Navier-Stokes equation. This is the eleventh ERC project awarded to ICMAT researchers since the programme began, which makes the ICMAT the institution that has obtained the greatest number of distinctions of this type in the field of mathematics, ahead of Oxford University and the Max Plank Institute of Mathematics.

Future leaders of international research

Jared Aurentz

Jared Aurentz (ICMAT) was one of the 30 scientists chosen for the "La Caixa" Postdoctoral Junior Leader Programme, adjudicated in 2018. His project lasts for three years and encompasses the areas of decision theory, risk analysis, machine learning and applied statistics. Its main objective is the development of mathematical models and a corresponding software package to facilitate the decision-making process. Much of the theoretical part of the project is based in adversarial risk analysis, a research line developed by David Ríos, the director of the ICMAT Axa Chair.

The best applied mathematician

Javier Gómez

Javier Gómez received the 2018 "Antonio Valle" SeMA Prize for a young applied mathematician. Gómez is currently an Assistant Professor at Princeton University (USA), and is also a member of the ICMAT Charles Fefferman Laboratory and a former PhD student at the Institute under the supervision of Diego Córdoba. His research work concerns the analysis of partial differential equations, in particular, in fluid dynamics. Javier Gómez was also awarded the Vicent Caselles Prize in 2017.

Other distinctions

- Felipe Ponce Vanegas, a doctoral student with Javier Ramos (CSIC-ICAMT), received the Yu Takeuchi Prize for his thesis, which he defended in May, 2018. This prize is awarded annually for the two best theses in the fields of mathematics, physics and statistics by the Colombian Academy of Exact Sciences. Ramos also received a distinction for his directorship of the work.

- José María Martell (ICMAT-CSIC) was an invited speaker at the Harmonic Analysis Research Programme, organized by the Institute of Advanced Studies as part of the Park City Mathematics Program (Park City, USA), which was held in July, 2018.

- Eva Gallardo (ICMAT-UCM) was invited to the Mittag-Leffler international institute for mathematical research to participate in an event in May, 2018. She was also a member of the panel of experts for the Marie Curie Grants (EC Europea H2020) in the field of mathematics, as well as obtaining a grant from the Spanish Ministry for Science, Research and Universities for a research stay at the University of Indiana (USA) between September and December, 2018.

- Javier Parcet (ICMAT-CSIC) was an invited speaker at the Oberwolfach Institute in May, 2018.

- Angelo Lucia, a member of the ICMAT Cirac Laboratory, was awarded the RSME José Luis Rubio de Francia Prize.

- The article "The unsolvable problem", authored by David Pérez García together with two other researches, was published on the front pages of the October issue of the well-known journal "Scientific American".

- Oscar García Prada, Luis Álvarez Cónsul and Tomás Gómez attended the "Workshop on Geometric Analysis and General Relativity" as invited speakers in Hong Kong in January, 2018.

- Oscar García Prada was an invited speaker at the *Nederlands Mathematisch Congress* held in Velhoven (the Netherlands) in April, 2018.

- In 2018, Tomás Gómez gave a talk at the "Moduli theory and derived category" conference (Pohang, South Korea).

- Fernando Chamizo was awarded first prize at the 4th edition of the CEI UAM+CSIC Scientific Essay Competition for his work entitled "Mathematics and the hidden science".

The ICMAT, a world leader in mathematics

ICM poster

Diego Córdoba attended the International Congress of Mathematicians (ICM), the most important mathematical event in the world, as an invited speaker when it was held in Brazil in August, 2018. He thus became the twelfth Spaniard to be given the opportunity to attend as a speaker at this forum, which was held for the first time in 1887. Every four years, the scientific committee of the ICM invites mathematical researchers who have obtained the most outstanding results in their respective fields to present them to the mathematical community. On this occasion, Córdoba spoke about his work in the field of partial differential equations; specifically, on the existence of singularities in the equations for modelling the dynamics of incompressible fluids in certain contexts.

6. Research Projects

National

In 2018, ICMAT researchers undertook 22 nationally funded research projects, which were as follows:

- ERC2018-092824 "Singular evolution of incompressible fluids". PR: Ángel Castro (75,000 €)

- RTC-2017-6591-1 "SecRating: Platform for calculating cybersecurity ratings and cyber risk management from suppliers" PR: David Ríos (262,452 €)

- EQC2018-005104-P "ACQUISITION OF SCIENTIFIC-TECHNICAL EQUIPMENT" PR: Ana M. Mancho (51,246.55 €)

- MTM2017-85934-C3-1-P "Analysis and geometry with applications to inverse problems"; PR: Keith Rogers (13,915 €)

- MTM2017-85934-C3-2-P: "Calculus of variations and geometry with applications to continuum mechanics and inverse problems"; PR: Luis Guijarro and Daniel Faraco (69,454 €)

- MTM2017-89423-P "Singularities in free surface flows"; PR: Marco Antonio Fontelos López (28,677 €)

- MTM2017-89976-P "The formation of singularities in incompressible fluids"; PR: Diego Córdoba Gazolaz (51,425 €)

- MTM2017-86875-C3-1-R "Advances in security risk management"; PR: David Ríos Insua (32,186 €)

- MTM2017-82690-P "Asymptotic invariants of groups"; PR: Andrei Jaikin (36,300 €)

- MTM2017-83496-P "Arithmetic and harmonic analysis"; PR: Antonio Córdoba and Fernando Chamizo (23,353 €)

- MTM2017-88385-P "Mathematical methods in quantum information"; PR: Carlos Palazuelos (35,332 €)

- MTM2017-84098-P "The mathematical foundations of quantum information technologies: convexity, sampling and operator algebras"; PR: Alberto Ibort (58,564€)

- MTM2016-76072-P "Geometric and numerical analysis of dynamical systems and applications to mathematical physics"; PR: David Martín de Diego and Daniel Peralta (65,219 €)

- MTM2016-79400-P "Symmetries in arithmetic, algebraic and symplectic geometry"; PR: José Ignacio Burgos Gil and Francisco Presas (75,141 €)

- MTM2016-81048-P "Geometry of coupled equations and moduli spaces"; PR: Oscar García Prada (45,133 €)

- MTM2016-75465-P "Partial differential equations: asymptotic dynamics and perturbations", PR: José María Arrieta and Aníbal Rodríguez Bernal (52,272 €)

- MTM2016-81700-ERC "Quantum harmonic analysis"; PR: Javier Parcet Hernández (35,000 €)

- MTM2016-80618-P: "Nonlinear partial differential equations and coupled systems of PDEs of second and higher order" PR: Eduardo Colorado Heras (15,972 €)

- MTM2016-76868-C2-1-P: "Geometry, Topology, Algebra and Cryptography in Singularities and its Applications". PR: Pedro Daniel González (90,750 €)

- SEV-2015-0554 "Severo Ochoa Excellence Programme"; PR: Diego Córdoba Gazolaz (4,000,000 €)

- S2018/TCS-4342 "Quantum information technologies in Madrid (quitemad-cm)". PR: Alberto Ibort and David Pérez García. (1,003,650 €)

- MTM2017-83496. "On the mathematical foundations of quantum information technologies: convexity, sampling and operator algebras - q-math+". PR: Alberto Ibort.

In total, funding for these projects amounted to more than 6 million euros.

International

Three new international projects were approved and launched in 2018, two of which received funding from the EU in the framework of the H2020 Programme:

- Diego Córdoba Gazolaz received funding from the European Research Council (Excellent Science first pillar) to conduct the "Nonlocal dynamics in incompressible fluids" project (NONFLU) (Ref: 788250; duration: 01/09/2018 –31/08/2023; contribution from the EU: 1,779,369 €). The aim of this project is to find new methods in the mathematical analysis of nonlocal and nonlinear partial differential equations. To this end, several physical scenarios of interest are presented in the context of incompressible fluids from the mathematical point of view as well as their applications.

- Ana M. Mancho received EU funding (second pillar of the H2020 Industrial Leadership Programme) to carry out the following Action of Innovation: "Integrated marine pollution risk assessment and emergency management in ports and coastal environments" (IMPRESSIVE) as part of the European consortium (Ref: 821922; Period: 01/12/ 2018 –31 / 05/2021; contribution from the EU: 1,913,701.25 €; ICMAT budget ICMAT: 176,315 €).

- Jared Aurentz received a La Caixa Foundation Junior Leader postdoctoral grant (Period: 1/09 / 2018 - 01 / 0921; Assigned budget: 305,700 €).

In 2018, there were 12 projects and active grants headed by ICMAT members and funded through international calls (from the European Commission for the FP7/H2020 Programme and other institutions. In total, they amounted to 9,607,300.12 €.

Detailed information on these projects is provided in the list below:

- Geometric and analytic aspects of isoparametric hypersurfaces (ISOPARAMETRIC). Miguel Domínguez Vázquez (postdoc) and Alberto Enciso Carrasco (PR). 16/04/2017 - 15/01/2019. Funder: EU. Amount: 111,125.34 €.

- Supporting Cyberinsurance from a Behavioural Choice Perspective (CYBECO). PR: CSIC node: David Ríos Insua. 01/05/2017 - 30/04/2019. PR: David Ríos. Funder: EU. Amount: 1,983,510.00 €, of which the ICMAT receives 251,250.00 €.

- Geometric Problems in PDEs with applications to fluid mechanics (ERC GEOFLUIDS). PR: Alberto Enciso. 01/03/2015 - 29/02/2020. Funder: EU. Amount: 1,256,375.00 €

- Invariant manifolds in dynamical systems and PDE (ERC INVARIANT). PR: Daniel Peralta. 01/01/201 - 30/06/2018. Funder: EU. Amount: 1,260,041.78 €.

- Harmonic Analysis, Partial Differential Equations and Geometric Measure Theory (HAPDEGMT). PR: José María Martell. 01/01/2014 - 31/12/2019. Funder: EU. Amount: 1,429,790.00 €.

- Stability and Transitions in Physical Processes (TraX). PR: UAM node: Florentino Borondo Rodríguez. 01/03/2017 - 28/02/2021. Funder: EU. Amount: 526,500.00 €, of which the ICMAT receives 63,000.00 €.

- Geometric function theory, inverse problems and fluid dynamics (GFTPRFD). PR: Keith Rogers. Funder: EU. Amount: 1,121,400.00 €.

- Spectral gaps in interacting quantum systems (GAPS). PR: David Pérez García. 01/08/2015 - 31/09/2021. Funder: EU. Amount: 1,462,750.00 €

- Non-local dynamics in incompressible fluids (NONFLU). PR: Diego Córdoba. 01/09/2018 - 31/08/2023. Funder: EU. Amount: 1,779,369.00 €.

- Integrated Marine Pollution Risk assessment and Emergency management Support Service In ports and coastal enVironmEnts (IMPRESSIVE). PR: CSIC node: Ana María Mancho. 01/12/2018 - 01/12/2021. Funder: EU. Amount: 1,913,701.25 €, of which the ICMAT receives 176,315.00 €.

- Dynamical systems and geophysical flows: new perspectives and applications (ONR1_2017). PR: Ana María Mancho. 30/09/2017- 30/09/2019. Funder: USA Office of Naval Research. Amount: 70,000.00 €.

- DMS-1901290 "Operator Algebras, Groups, and Applications to Quantum Information" IP: David Kerr (Texas A&M) y Fernando Lledó (21/12/2018 - 29/02/2020): $36.000

7. Severo Ochoa Programme

Some of the main activities funded through the Severo Ochoa Programme in 2018 are as follows:

- Research visits by internationally prestigious mathematicians such as Nigel Hitchin (Oxford University, United Kingdom), Charles Fefferman (Princeton University, USA), Kari Astala (University of Helsinki, Finland), Ignacio Cirac (Max Planck Institute of Quantum Optics, Germany), Rafael de la Llave (Georgia Institute of Technology, USA), Tobias Colding (MIT, USA), thanks to the ICMAT Laboratory Programmes and Distinguished Professors.

- The launching of a new scheme for the co-funding of expenses for stays by leading speakers in their respective fields during the different seminars of the Institute.

- Thematic Programmes on moduli spaces, harmonic analysis and its applications, and group theory. In addition, five congresses, two schools and one course are also included.

- Seven grants for master students enrolled in one of the three universities affiliated to the Institute.

- 25 Introduction to Research grants for students in the final university year of their Mathematics studies.

- Appointment of four new postdoctoral researchers.

- Funding for most of the scientific activities conducted by the Institute (thematic trimesters, congresses, schools, etc) (see Section 8 for details).

8. Scientific Activities

In 2018, 15 congresses were held at the Institute, which means an average of 1.25 per month. Different disciplines were covered, ranging from geometry, dynamics and control to harmonic analysis, moduli spaces and group theory. It is also worthwhile to mention three thematic trimesters (on these last three subjects) that attracted leading international experts in their respective fields to the Institute. In addition, the regular activity of the Institute continued apace with weekly seminars and discussions organized in collaboration with the UAM and the UCM. Moreover, 16 doctoral theses were read, and as is customary every year another JAE school was held for master and final year university students wishing to learn about the world of mathematical research. Over the course of the year, a total of more than 250 scientific activities were held at the centre, which means approximately one activity every day not counting weekends. This reflects the intense activity undertaken by the ICMAT and which makes it one of the epicentres of international mathematical research.

Trimesters, schools, congresses and courses

The congresses and courses held at the centre during 2018 are as follows:

Thematic Programme: "L2-invariants and their analogues in positive characteristic"

February 19th – June 15th.

Organizers: Y. Antolin (ICMAT), J. Aroca (ICMAT), J. Aramayona (ICMAT), A. Jaikin (ICMAT) y D. López (ICMAT).

Website: https://www.icmat.es/rt/l2invariants2018

Image: ICMAT

L2 invariants School

The thematic programme was devoted to the recent developments in the theory of L2-invariants and their analogues in positive characteristic. Historically, the theory of L2 invariants has its origins in a work by Michael Atiyah, in which he proposed an extension of the Atiyah-Singer index theory of elliptic differential operators on compact manifolds to the non-compact case. The modern definition of these invariants is more algebraic and uses the language of CW-complexes. The analogue of the first L2-Betti number in positive characteristic, the p-gradient, was introduced by M. Lackenby in his study of hyperbolic 3-manifold groups.

The study of L2 invariants is linked to topology, geometry, global analysis, operator theory, ring theory, group theory and K-theory.

The objective of this programme was to bring together the leading specialists in this field and included a school as well as several advanced courses in the latest developments. It provided a great opportunity to train young researchers in an area that has been successful in the study of important problems such as the Baum-Connes conjecture and the Hanna Neumann conjecture, while being an important source of tools and ideas for tackling very interesting open problems. The following activities were organized in the framework of this thematic trimester:

- Inaugural Colloquium: "Introduction and survey on L2-invariants", Wolfgang Lück (February 27th).

- Introductory School (February 26th – March 9th).

- Advanced Courses:

  o Sofic entropy and finite automata (Miklos Abert) (March 12th, 13th and 15th).

  o Classical and L2-torsion of knots and 3-manifolds (Stefan Friedl and Fabian Hennecke) (March 19th, 20th, 22th y 23th).

  o Fuglede-Kadison Determinant and Sofic Entropy (Lewis Bowen) (April 16th, 17th, 19th y 20th).

  o The theory of epic *-regular R-rings and its application to the study of L2-Betti numbers (Andrei Jaikin, Fabian Henneke, Diego López) (April 23th -26th).

- Seminars.

- Workshop (June 4th -8th).

Thematic Programme: "Real Harmonic Analysis and Its Applications to Partial Differential Equations and Geometric Measure Theory"

May 7th - June 9th

Organizers: S. Bortz (U. Minnesota), J.M. Martell (ICMAT) y S. Mayboroda (U. Minnesota).

Website: https://www.icmat.es/RT/2018/HAPDEGMT

Image: ICMAT

Chema Martell and Steve Hoffman

Harmonic has and continues to be an active field of research, both from the point of view of pure mathematics and from that of applications to problems in other fields. This trimester was dedicated to the study of the interface between harmonic analysis with partial differential equations and geometric measure

theory. The aim was to bring together various experts in this field, as well as young mathematicians, in order to discuss important recent developments and foster future collaboration.

The research programme consisted of three main components. Firstly, a school in which topics on the frontiers between harmonic analysis, partial differential equations and geometric measure theory were addressed, aimed mainly at young graduate and post-graduate students as well as mathematicians from other fields who wished to familiarize themselves with the field. Secondly, a congress entitled " Workshop on Real Harmonic Analysis and its Applications to Partial Differential Equations and Geometric Measure Theory: on the occasion of the 60th birthday of Steve Hofmann", and finally a series of seminars on specific topics conducted by leading researchers in the field.

- Workshop on Real Harmonic Analysis and its Applications to Partial Differential Equations and Geometric Measure Theory: on the occasion of the 60th birthday of Steve Hofmann (May 28th - July 1st).

  Among the 16 speakers were five mathematicians, winners of the prestigious Salem Prize, awarded annually to young researchers for their significant contributions to the field of Analysis (Guy David, Carlos Kenig, Michael Lacey, Xavier Tolsa and Alexander Volberg); Pascal Auscher, director of the National Institute of Mathematical Sciences and its interactions with the CNRS in France; and Jill Pipher, Vice President for Research at Brown University and President Elect of the American Mathematical Society (USA).

- School on Real Harmonic Analysis and its Applications to Partial Differential Equations and Geometric Measure Theory (May 21th – 25th).

  - Quantitative absolute continuity of harmonic measure (S. Hofmann, U. Missouri)

  - Harmonic measure via blow up methods and monotonicity formulas (X. Tolsa, ICREA).

  - Almost minimizers in variational problems (T. Toro, U. Washington).

- Seminars.

Thematic Programme on moduli spaces

September 15th - December 15th

Organizers: L. Álvarez-Cónsul (ICMAT), S. Bradlow (U. Illinois at Urbana-Champaign), X. Chen (U. Stony Brook), M. García-Fernández (ICMAT), O. García-Prada (ICMAT) y T. L. Gómez (ICMAT).

Website: https://www.icmat.es/RT/2018/RPMS/index.php

This programme was devoted to moduli space theory and its relation with mathematical physics. The main aims were to facilitate research and knowledge transfer in this subject and in related areas. Moduli spaces are central objects that appear in classification problems in geometry. Their importance has grown over the years due to the appearance of these spaces in diverse areas of mathematics such as differential geometry, topology, algebra and theoretical physics.

The research programme was focused on two basic topics belonging to the general theory of moduli spaces: Higgs bundles, mirror symmetry and Langlands duality; gauge theory, special holonomy and special metrics. It included two schools and workshops, a visitors' programme and a regular seminar. The trimester was linked to the ICMAT Severo Ochoa Donaldson-Hitchin Laboratory.

New Trends in Higgs Bundle Theory

The activities organized were as follows:

- Group actions in algebraic and symplectic geometry (October 2nd - 3rd).
- School and Workshop on New Trends in Higgs Bundle Theory (November 12th -16th).
- School and Workshop on Special Metrics and Gauge Theory (December 10th -14th).
- Moduli Seminar (September 15th - December 15th).
- Vertex Algebra Seminar (September 15th' - December 15th).

Harmonic Analysis in Winter

January 8th – 12th

Organizers: José Manuel Conde Alonso (Brown University), Teresa Luque (Universidad Complutense de Madrid), José María Martell (ICMAT), Javier Parcet (ICMAT)

Website: https://sites.google.com/view/josecondealonso/research/harmonic-analysis-in-winter

60 Years Alberto Ibort Fest - Classical and Quantum Physics: Geometry, Dynamics and Control

March 5th - 9th

This was an interdisciplinary congress dedicated to Alberto Ibort on the occasion of his 60th birthday. Ibort has made important contributions to many fields of mathematics and physics. Most of his scientific activity has been motivated by geometric ideas, concepts and tools that are closely related to classical dynamics and quantum mechanics.
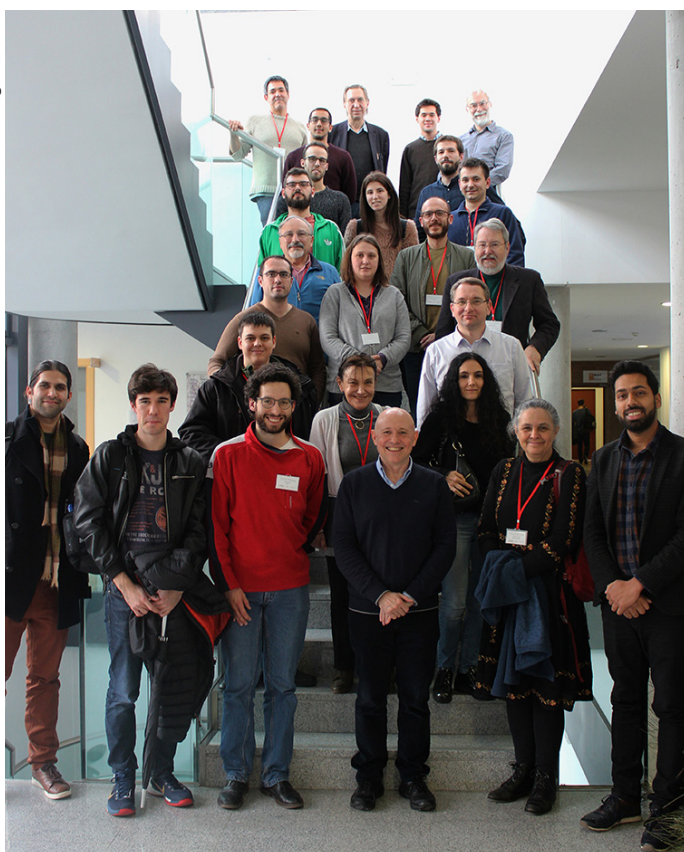
Website: https://www.icmat.es/congresos/2018/IBORT-FEST/

Congreso Alberto Ibort

Agapi days I. Lab Kari Astala

March 15th

Linked to the Kari Astala ICMAT Laboratory, these day sessions devoted to recent results in the field of analysis and geometry with applications to inverse problems are organized periodically. This was the first of these sessions.

Website: https://dcain.etsin.upm.es/agapi/agapi_I.html

Agapi days II/Lab Kari Astala

May 3rd and 4th

The second activity was organized in the framework of the AGAPI research group, with links to the Kari Astala ICMAT Laboratory.

Website: https://dcain.etsin.upm.es/agapi/agapi_II.html

SMGT

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Bringing Young Mathematicians Together

May 7th - 9th

Organizing committee: Ángela Capel (ICMAT-UAM), Jesús Ocáriz (ICMAT-UAM), Patricia Contreras Tejada (ICMAT-CSIC), Roi Naveiro (ICMAT-CSIC) y David Alfaya (ICMAT-CSIC).

BYMAT Conference

This conference was organized by and aimed at PhD students in all the areas of mathematics and related disciplines, and, in general, any young people who use mathematics in their work.

Website: https://www.icmat.es/congresos/2018/BYMAT/

TraX International Conference 2018

May 9th - 20th

Organizers: Fabio Revuelta Peña, Rosa María Benito and Juan Carlos Losada.

The 2018 TraX International Conference was organized as part of the TraX European Project (Stability and Transitions in Physical Processes). The main aim of this conference was to bring together physicists, chemists and mathematicians who work on transition state theory and molecular ionization to discuss the latest advances in both subjects and to establish new research lines and collaborations.

Website: http://www.gsc.upm.es/trax2018/index.html

XXX Memorial Rubio de Francia. Geometry of Measures

May 25th

Geometry of Measures (T. Toro, U. Washington).

Website: https://www.icmat.es/eventos_web/cursos_conferencias_grupos/Conferencia-MemorialRubioFrancia2018.pdf

Agapi days III - Nonlineal difusion - Lab Kari Astala

June 4th

The third activity organized in the framework of the AGAPI research group, with links to the Kari Astala ICMAT Laboratory.

Website: https://www.icmat.es/eventos_web/cursos_conferencias_grupos/Agapi-Kari-Astala-04-06-18.pdf

Special Session On Dynamics

June 13th

Website: https://www.icmat.es/eventos_web/cursos_conferencias_grupos/Special-Session-13-06-18.pdf

Number Theory Minicourse on the Arithmetic of Elliptic Curves

June 20th, 22nd, 25th, 26tg and 27th

Organizer: Daniele Casazza (ICMAT).

Website: https://www.icmat.es/eventos_web/cursos_conferencias_grupos/180618_Minicurso_ellipticcurves_MartinezCardenal.pdf

JAE School of Mathematics 2018

June 18th - 29th

Organizers: Patricia Contreras (ICMAT-CSIC) and Carlos Palazuelos (ICMAT-UCM).

JAE School

The JAE School of Mathematics is organized by the ICMAT and takes place every summer. It is aimed at master and final year degree students who are interested in learning about mathematical research and its applications. Over the course of two weeks, the students are introduced to fields of mathematics that are not usually included in university courses. The goal of the School is to encourage students to take up a research career and to interact with the top rank mathematicians who impart the JAE courses.

Website: https://www.icmat.es/events/JAESchool/programme2018

Number Theory Minicourse on Kolyvagin's Theorem and the Birch-Swinnerton-Dyer Conjecture

July 3rd - 5th

Organizer: Daniele Casazza (ICMAT)

Website: https://www.icmat.es/eventos_web/cursos_conferencias_grupos/Minicurso_Carlos_de_Vera_3-to-5-07-2018.pdf

Mathematical Foundations of Supervised Machine Learning

October 1st - 5th

Website: https://www.icmat.es/eventos_web/cursos_conferencias_grupos/Curso-2018-MichaelMWolf.pdf

Groups in Madrid

November 22nd - 23rd

Organizers: Yago Antolín, Javier Aramayona, Andrei Jaikin-Zapirain and Carolina Vallejo.

This was the fourth edition of *Grupos en Madrid*, a conference lasting two days and devoted to recent developments in group theory.

Web: http://verso.mat.uam.es/~yago.antolin/groupsinmadrid/main.html

Software Carpentry

November 28th – 30th

The purpose of Software Carpentry was to help researchers to complete their work more smoothly and in a shorter time by teaching them basic computational research skills. This practical workshop covered basic tools and concepts, including programme design, control of versions, data management and task automation. The participants were encouraged to help each other and to apply what they were learning to their own research problems.

Website: https://adgdt.github.io/2018-11-28-cftmat/

![ICMAT logo](ICMAT - Instituto de Ciencias Matemáticas)

ICMAT Laboratories

In 2016, the second ICMAT Laboratories was launched, complemented by the Distinguished Professors scheme and funded through the Severo Ochoa Excellence Programme (2015-2019). As principle Severo Ochoa researcher and co-director of the Charles Fefferman Laboratory, Diego Córdoba, explained: "The main aim of this programme is to link leading mathematicians directly to the Institute in a scientific way. It provides them with the opportunity to spend one or two months a year working alongside people from the centre". Furthermore, these laboratory heads participate in other activities at the ICMAT, such as symposia, workshops, courses and work meetings, thereby creating an "opportunity for PhD students and postdoctoral researchers to enter into direct contact with these outstanding figures, tell them what they are doing and thereby have the chance to go to the Institutions to which these scientists belong", says Córdoba. The activities at each of these laboratories undertaken throughout 2018 are as follows:

Kari Astala Lab

Director: Kari Astala, professor at the University of Helsinki. Among the distinctions he has received, we may mention the Salem Prize (1994) and the Finnish Cultural Foundation Prize (2011).

Co-director: Daniel Faraco (ICMAT-UAM)

Other members: Luis Guijarro (ICMAT), Keith Rogers (ICMAT-CSIC), Alberto Ruiz (ICMAT-UAM), Pablo Angulo (ICMAT-UAM), Sauli Lindberg (ICMAT-UAM), Martí Prats (ICMAT-UAM), Renato Lucà (ICMAT-CSIC), Marcos de la Oliva (ICMAT-UAM), Jorge Tejero (ICMAT-CSIC), José Luis Fernández (UAM) and Fabricio Macià (Universidad Politécnica de Madrid).

Research areas: Harmonic analysis, in particular, the study of elliptic operators.

Sessions of the Agapi days were organized in 2018 (second edition between May 3rd-4th and third edition on June 4th). Researchers from the Universities of Leipzig, Buenos Aires and Oxford interspersed their conferences with researchers from the ICMAT and the UAM with these meetings in order to share their latest results on subjects of interest in the laboratory. Specifically, special attention was placed in 2018 on nonlinear diffusion. Furthermore, Jan Kristensen (Oxford University) and Bernd Kirchheim (University of Leipzig) also came to the ICMAT last year as visitors to the centre.

Image: ICMAT
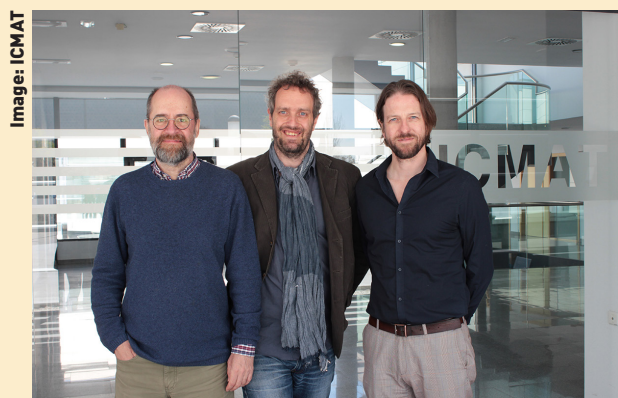
Kari Astala, Daniel Faraco and Keith Rogers

Ignacio Cirac Lab:

Director: Ignacio Cirac, director of the Max Planck Institute of Quantum Optics. He was awarded the Principe de Asturias Prize in 2006, the BBVA Frontiers of Knowledge Prize in 2008 and the Wolf Prize for Physics in 2013.

Co-director: David Pérez-García (UCM-ICMAT)

Other members: Alberto Ibort (ICMAT-UC3M), Carlos Palazuelos (ICMAT-UCM), Andrea Coser (ICMAT-UCM), Sofyan Iblisdir (ICMAT-UCM), Cecilia Lancien (ICMAT-UCM), Giannicola Scarpa (ICMAT-UCM), Ángela Capel Cuevas (ICMAT-UAM), José Garre Rubio (ICMAT-UCM), G. Marmo (Santander Chair of Excellence/UC3M), Norbert Schuch (Max Planck Institute of Quantum Optics), Germán Sierra (IFT) and Frank Verstraete (University of Ghent).

Research areas: Information theory and quantum computation, especially connections with the study and characterization of properties that may appear in materials at very low temperatures, in which quantum mechanics determine the behaviour of the systems.

Two events were organized in 2018 within the framework of Cirac Laboratory: the Mathematical foundations of supervised machine learning course, given by Cirac himself on October 1st, and "Mapping topological to conformal field theories through strange correlators", in November.

Image: ICMAT

David Pérez García and Ignacio Cirac

Donaldson-Hitchin Lab

Directors:

- Simon Donaldson is a professor with the Simons Center for Geometry and Physics at the University of Stony Brook (New York, USA) and at Imperial College London (United Kingdom). He was awarded a Fields Medal in 1986 and the Breakthrough Prize in Mathematics in 2014.

- Nigel Hitchin is emeritus professor of geometry at Oxford University. He was awarded the Shaw Prize in 2016.

Co-director: Oscar García-Prada (CSIC-ICMAT).

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Other members: Luis Álvarez-Cónsul (ICMAT-CSIC), Tomás Gómez de Quiroga (ICMAT-CSIC), Francisco Presas (ICMAT-CSIC), Mario García-Fernández (ICMAT-CSIC), David Alfaya Sánchez (ICMAT-UAM), Lucas Branco (Oxford University), Luis Ángel Calvo Pascual (ICMAT-CSIC), Andoni de Arriba de la Hera (ICMAT), Aleksander Doan (Stony Brook), Manuel Jesús Pérez García (ICMAT-CSIC), Steven Bradlow (University of Illinois at Urbana-Champaign), Xiuxiong Chen (Stony Brook), Xenia de la Ossa (Oxford University), Peter Gothen (Universidade do Porto), Alastair King (Bath University), Ignasi Mundet i Riera (Universitat de Barcelona), Vicente Muñoz (UCM), Song Sun (Stony Brook) and Richard Thomas (Imperial College London).

Research areas: Higgs bundles, mirror symmetry and Langlands duality; Kähler-Yang-Mills equations related to moment transforms; Gauge theory, special holonomy and generalized geometry.

The "Research in moduli space programme" was organized in this laboratory at the ICMAT between September 15th and December 15th. This included a seminar and two schools and conferences devoted to new challenges arising in this field of research, in which Donaldson and Hitchin are international leaders.

In addition, apart from the thematic programme, several seminars on geometry were held, dedicated to topics addressed at the laboratory, such as harmonic surfaces and the Yang-Mills-Higgs flow.
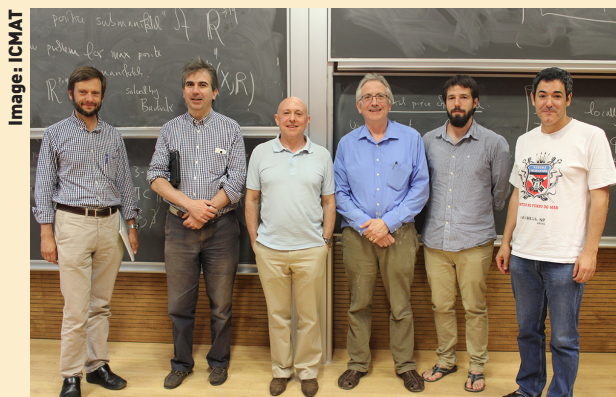
Donaldson-Hitchin Lab group

Charles Fefferman Lab

Director: Charles Fefferman is a professor at Princeton University (USA). He was a Fields Medal winner in 1978. His work has had an enormous influence in different fields of mathematics, such as mathematical analysis, partial differential equations, Fourier analysis, mathematical physics, fluid dynamics, neural networks and differential geometry.

Codirector: Diego Córdoba Gazolaz (CSIC-ICMAT).

Other members: Ángel Castro (ICMAT-UAM), Nastasia Grubic (ICMAT-CSIC), Omar Lazar (ICMAT-CSIC), Diego Alonso (ICMAT-UAM), Daniel Lear (ICMAT-CSIC), Tania Pernas (ICMAT-CSIC), Francisco Gancedo (Universidad de Sevilla) and Javier Gómez-Serrano (Princeton University).

Research areas: Fluid mechanics; in particular, the study of the formation and propagation of singularities in Navier-Stokes equations.

This laboratory is a continuation of the first Fefferman Laboratory (2012-2016). In 2018, Charles Fefferman imparted two seminars at the ICMAT: "INTERPOLATION AND APPROXIMATION IN SEVERAL VARIABLES" (January 17th) and "GRAPHENE" (January 24th)

Fefferman Lab group

Colloquia

The programme of joint colloquia with the UAM and UCM was continued throughout 2018, as well as the special colloquia organized by the ICMAT.

ICMAT-UAM Colloquia

Co-ordinators: Yago Antolín, Javier Aramayona and Tomás Luis Gómez de Quiroga.

Colloquia organized:

- Topology Meets Neuroscience. Kathryn Hess (EPFL). 23rd of November.
- Minimal Lagrangians And Where To Find Them. Jason Lotay (UCL). 26 of October.
- Nevanlinna-Pick Interpolation From A Functional Analytic Viewpoint. Tirthankar Bhattacharyya (IISc Bangalore). 15 of June.
- Quantum Dynamics Of Systems Under Repeated Observation. Jürg Fröhlich (ETH Zurich). 23 of May.

- The Level Set Method For Motion By Mean Curvature. Tobias Holck Colding (MIT). 16 de marzo.

Kathryn Hess

- Introduction And Survey On L2-Invariants. Wolfgang Luck (University of Bonn). 27 of February.
- Knots, Polynomials And $SL_2(C)$. Julien Marchè (Institut de Mathématiques de Jussieu). 12 of January.

ICMAT-UCM Colloquia

Co-ordinators: Piergiulio Tempesta y Marco Castrillón López.

Colloquia organized:

- Recent Advances On Applications Of Lie Systems Theory In Classical And Quantum Physics. José F. Cariñena, University of Zaragoza. 11 of May.
- Almost Reducibility. Artur Avila, IMPA, Rio de Janeiro. 29 of May.
- Special Functions, Lie Algebras And Rigged Hilbert Spaces. Mariano del Olmo, University of Valladolid. 17 of December.

Special Colloquia:

- A Survey On Stationary Isothermic Surfaces And Their Related Problems. Shigeru Sakaguchi, Tohoku University. 12 of September.
- Moduli Spaces Of Unstable Curves. Frances Kirwan, Oxford University. 3 of October.

Image: ICMAT

Frances Kirwan

Seminars

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

- Seminar of Analysis and Aplications. Coordinator: José María Martell.
- Seminar of Geometry. Coordinators: Cristina Sardón & Mario García Fernández.
- Seminar of Applied Mathematics. Coordinators: Jezabel Curbelo & Carlos Escudero.
- Seminar of Number Theory. Coordinators: Daniele Casazza, Enrique González Jiménez & Daniel Macías Castillo.
- Seminar of Group Theory. Coordinator: Yago Antolín.
- Junior Seminar. Coordinators: Ángela García Capel & Nikita Simonov.
- DataLab Seminar. Coordinators: David Gómez-Ullate & Roi Naveiro.
- Seminar of Communtative Algebra-Algebraic and Aritmetic Geometry UAM-ICMAT. Coordinator: Ana Bravo.
- Seminar on PDE's and Fluid Mechanics. Coordinators: Diego Córdoba & Ángel Castro.
- Q-Math Seminar. Coordinator: Juan Manuel Pérez Pardo.

A total of 201 seminars were held in 2018, divided into the following different categories:

- Junior: 12
- Geometry: 35
- Analysis and Applications: 18
- Applied Mathematics: 14
- Number Theory: 23
- Group Theory: 32
- DataLab: 7
- Commutative Algebra-Algebraic Geometry and Arithmetic UAM-ICMAT: 9
- PDEs and Fluid Mechanics: 18
- Q-Math: 15
- Others: 18

9. Institutional Networks

The Institute belongs to several research support networks, such as the *Red Estratégica de Matemáticas* (REM – Strategic Network of Mathematics), the SOMMa network, consisting of the Severo Ochoa Centres of Excellence and the María de Maeztu Units, and the ERCROM (European Research Centres in Mathematics) network. In 2018, the ICMAT has seconded the creation of the first mathematical outreach network, the DiMa, by hosting the website of this network, among other actions.

Strategic Network of Mathematics

The main mission of the *Red Estratégica de Matemáticas* (REM), created in 2017, is to articulate the advances of the Spanish mathematical community by providing a strategy to improve its presence on the international scene, as well as creating synergies among the scientific-mathematical community and the impact of socio-economic of mathematical research in Spain The REM has a special interest in outreach and the transfer of mathematical technology, orienting I+D towards the needs of companies, industry and public administrations.

The ICMAT is one of the nodes of this Network, together with Public Institutions of Higher Education in Spain, the *Red Española Matemática-Industria* (math-in), the *Red de Institutos Universitarios de Matemáticas* (RedIUM), the University of Seville Institute of Mathematics (IMUS) – the coordinator- and the Basque Center for Applied Mathematics (BCAM).

From the ICMAT, David Martín sits on the Executive Committee and Ágata Timón is in charge of the REM outreach activities.

This study states that mathematics is already responsible for "more than one million jobs" – 6% of the total workforce – and more than 10% of GDP in Spain. Furthermore, the intensive work carried out in the profession of mathematics will cause these figures to rise in the coming years. However, the study also warns that the fabric of the Spanish business world is nourished less by mathematics than that of its neighbouring countries, and if this situation does not change the Spanish economy will lose its competitiveness.

Mathematics constitutes a "strategic" asset that "will accelerate economic growth", according to the report entitled "The socio-economic impact of mathematical research and mathematical technology in Spain".

Full report: https://institucionales.us.es/remimus/wp-content/uploads/2019/04/ESTUDIO-MATEMATICAS-REM-AFI_ESP.pdf

Severo Ochoa centres of excellence SOMMa network

Since October, 2017, The ICMAT has formed part of the SoMMa alliance, also consisting of the Severo Ochoa Centres of Excellence and the María de Maetzu Units of Excellence. The principle objective of this network is to promote Spanish excellence in research and strengthen its social impact both nationally and internationally. In addition, it also fosters participation in outreach activities aimed at key sectors of society, such as the media, the scientific community, politicians and policy makers and the public in general. Furthermore, both within and outside the alliance it promotes the exchange of scientific and technological knowledge with the scientific community worldwide, thereby facilitating interdisciplinary collaboration and the spread of excellence. Likewise, it supports and contributes to scientific policy in Spain and internationally; attracts and integrates talent, stimulating mobility in Spain, and seeks synergies and opportunities for collaboration with other research institutes and universities in order to energize Spanish science.

In 2018, and in collaboration with the CNIO, the network organized a meeting called "100xciencia 3" which was open to the general public and the media. The meeting, held on the 15th and 16th of November, was focused on scientific education, citizen science and the participation of society in the present and future of science. It brought together members of the SOMMa and others to share in the success of projects carried out in the areas mentioned above. In addition, several round-table discussions were held with different actors involved in science, the media and scientific policy.

Moreover, from the ICMAT, Patricia Benito particIpated in the Transfer Working Groups (WG); Miguel Anchuelo in *Gerentes*, and Esther Sources in the National Calls. For her part, Ágata Timón is a member of the Alliance's editorial board.

The DiMa Network

The *Red de Divulgación Matemática* (DiMa – Mathematical Outreach Network) is a platform consisting of disseminators of mathematics in Spain and enjoys the support of institutions (universities and research centres) and mathematical societies, among which is the ICMAT. The DiMa is a cooperative space for the sharing of experiences, materials, learning and reflection on mathematical outreach.

The objectives of the DiMa Network are as follows:

- Establish synergies among mathematical outreach workers.
- Develop training activities around mathematical outreach.
- Incentivize the involvement of young people in mathematical outreach activities.
- Make it clear to public bodies that they should take outreach into account both in researchers' and teachers' CVs and in public calls (for projects, grants, competitive exams and so on).

The founding meeting of the Network in Zaragoza was held in 2018. This was the "Congress on Mathematical Outreach Technologies", which took place in the city on May 11th and 12. It was organized by the University of Zaragoza Institute of Mathematics and Applications (IUMA) on invitation from the DiMa. In addition to presenting different outreach experiences and serving as a meeting place for disseminators of mathematics in Spain, the first guidelines were approved at this founding congress as well as the direction of the Network in the coming years.

DiMa Zaragoza 2018

17 researchers completed their PhD theses at the ICMAT in 2018, the titles, authors and supervisors of which are listed below:

1. Algorithmic Resolution Of Singularities And Nash Multiplicity Sequences. Beatriz Pascual Escudero, ICMAT-UAM. Directores: Ana Bravo (ICMAT-UAM) and Santiago Encinas (Universidad de Valladolid). Date: January 19th.

2. Nonautonomous Dynamical Systems: From Theory To Applications. Francisco Balibrea Iniesta, ICMAT. Supervisors: Stephen Wiggins (Bristol University) and Ana María Mancho (ICMAT). April 27th.

3. Aspects Of Global Dynamics In Nonautonomous Dynamical Systems. Carlos Lopesino Jiménez de Zadava Lissón, ICMAT. Supervisors: Stephen Wiggins (Bristol University) and Ana María Mancho (ICMAT). April 27th.

4. On The Oscillatory Nature Of Several Fourier Multipliers. Eric Latorre, ICMAT-CSIC. Supervisor: Antonio Córdoba (ICMAT-UAM). May 17th.

5. Asymptotic Techniques In The Analysis Of Invariant Manifolds Of Dynamical Systems. Francisco Javier Torres de Lizaur, ICMAT. Supervisor: Daniel Peralta Salas (CSIC-ICMAT). June 14th.

6. Monodromies As Tête-À-Tête Graphs. Pablo Portilla Cuadrado, UCM-ICMAT. June 15th.

7. Métodos Algebraicos En Criptografía Multivariable. Jorge Linde Díaz (ICMAT-UCM). Supervisor: Ignacio Luengo (ICMAT-UCM). June 21st.

8. An Integral Representation And Pointwise Inequality Of The Fractional Laplace-Beltrami Operators. Ángel D. Martínez (ICMAT-UAM). Supervisor: Antonio Córdoba (ICMAT-UAM). June 22nd.

9. Global Approximation Theorems For Partial Differential Equations And Applications. María Ángeles García Ferrero, ICMAT-UCM. Supervisor: Alberto Enciso (ICMAT-CSIC). July 17th.

10. Augmented Bundles And Real Structures. Luis Ángel Calvo Pascual, ICMAT. Supervisor: Óscar García-Prada (ICMAT). July 26th.

11. Automorphisms Of Higgs Bundle Moduli Spaces For Real Groups. Manuel Jesús Pérez García, ICMAT. Director: Óscar García-Prada (ICMAT). July 27th.

12. Automorphism Group Of The Moduli Space Of Parabolic Vector Bundles Over A Curve. David Alfaya Sánchez (ICMAT). Supervisor: Tomás Luis Gómez de Quiroga (ICMAT). October 26th.

13. Topological Quantum Field Theories For Character Varieties. Ángel González Prieto, UCM-ICMAT. Supervisors: Marina Logares (University of Plymouth) and Vicente Muñoz (Universidad de Málaga). October 29th.

14. Contribuciones Al Análisis De Riesgos Adversarios. Jorge González Ortega (UCM-ICMAT). Supervisor: David Ríos Insua. November 29th.

15. Modular Forms And Lattice Point Counting Problems. Carlos Pastor Alcoceba, ICMAT. Supervisor: Fernando Chamizo Lorente (UAM-ICMAT). December 14th.

16. Semiclassical Measures And Asymptotic Distribution Of Eigenvalues For Quantum Kam Systems. Víctor Arnaiz Solórzano, ICMAT-UAM. Directores: Fabricio Macià Lang (UPM) y Keith Rogers (ICMAT). December 18th.

17. Sharp Estimates For Linear And Nonlinear Wave Equations Via The Penrose Transform. Giuseppe Negro, ICMAT, Université Paris 13. Supervisors: Thomas Duyckaerts and Keith Rogers (ICMAT). December 21st.

11. Outreach and communication activities

The ICMAT maintained an intense outreach and communication activity throughout 2018, conducted by the Communication Office staffed by Laura Moreno Iraola and Ágata Timón G Longoria, with advice and consultation from Daniel Peralta, Alberto Enciso, David Martín de Diego and Antonio Córdoba. In addition to continuing regular activities in 2018, such as press releases, the ICMAT newsletter, the Café y Teoremas section in the El País daily and the organization of activities in the Science Week, a fresh rounds of activities was launched such as the outreach series, "Mathematical Revolutions", and the organization of the "Numbers before Christmas" mini-course. A full list of these activities is given below:

ICMAT Newsletter

The ICMAT publishes a biannual news bulletin which reports on what happens in a centre of mathematical excellence. This newsletter presents subjects of interest regarding current mathematical research, as well as the scientific activities of the centre and personal profiles of notable figures in the scientific community.

The authors of these articles are researchers from the Institute itself or other mathematicians who collaborate with the ICMAT, as well as a team of professional journalists in the field of mathematical communication and outreach. Two issues of the ICMAT newsletter ere published in 2018:

• Newsletter #16 (First semester 2018)

ICMAT Newsletter #16
First quarter 2018
CSIC - UAM - UC3M - UCM

INSTITUTO DE CIENCIAS MATEMÁTICAS

EDITORIAL

Ten years of the ICMAT

The agreement for the creation of the Institute of Mathematical Sciences was signed ten years ago. This took place on October 29th, 2007, after a long process since the decision was first taken in 2005 by the board of the Consejo Superior de Investigaciones Científicas (CSIC), presided at the time by Carlos Martínez Alonso, to set the institute up.

In 2005, the Departamento de Matemáticas del Instituto de Matemáticas y Física Fundamental (IMAFF) tabled an independent proposal for the 2006-2009 Strategic Plan, the aim of which was to bring it up to date and provide it with a more appropriate structure. That was probably the most important initiative undertaken in the history of mathematics at the CSIC. The plans of each institute were later coordinated with those of the areas and those of the central organization in order to draw up a global plan which, after an international and independent evalution, would lead to a restructuring and the assignment of financial and human resources in accordance with that evaluation.

The plan for the Departament of Mathematics was evaluated by an external committee headed by the current chair of the European Research Council (ERC), Jean-Pierre Bourguignon, who pointed out the importance of mathematics within the CSIC; the extraordinary quality of the young researchers we had been able to bring together; the need for a suitable headquarters, and the duty of raising the profile of the discipline at the CSIC by the creation of an institute of mathematics. This centre eventually took the form of a joint institute consisting of the CSIC and the three Madrid universities, with the following objectives (as set out in the introduction to the official agreement):

"... an appropriate channel for the coordination and development of ever-increasing research activity in the Mathematical Sciences and the creation of further channels for the transfer of mathematical knowledge to other sciences as well as to technological, industrial and financial sectors."

I had the honour of being named acting director charged with carrying the project forward. I began my professional career at the CSIC one morning in January, 1986, when I arrived at the main campus and took up my duties as Scientific Researcher in my office at 123, Serrano Street. Two decades later, that signature in 2007 represented a significant achievement, the result of a struggle to restore mathematics to its natural place in the CSIC. As I said at the time (and still maintain today): "The CSIC cannot live without mathematics, and neither can the Spanish mathematical community be effective without the CSIC".

Manuel de León, ICMAT director.

Image: ICMAT

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Newsletter #16

• Newsletter #17 (Second semester 2018)

ICMAT Newsletter #17
Second semester 2018
CSIC - UAM - UC3M - UCM

INSTITUTO DE CIENCIAS MATEMÁTICAS

EDITORIAL

Challenges of Mathematical Biology

Andreas Deutsch (TU Dresden). A hiking mathematical biologist encounters a shepherd. The shepherd is so happy that he offers the mathematical biologist one of his sheep should he be able to calculate the exact number of individuals in his herd. The mathematical biologist estimates the number to perfection. Later one can watch the mathematical biologist hiking further together with the shepherd's dog. This joke nicely expresses the essence of mathematical biology but also the danger of mathematical abstraction. The strength of mathematical biology is not just to calculate quantities but to abstract common patterns at different biological organisation levels which is exaggerated by the mathematical biologist above. The interface between the biological problem and the mathematical analysis is the model. Mathematical biology fosters mathematical reasoning to the explanation of biological phenomena, and can provoke new types of mathematical problems. Thus, ecological interactions have motivated new questions in mathematical game theory, and properties of cancer cells have triggered the study of density-dependent diffusion equations.

Today mathematical biology bustles with activity. Under the new umbrella of systems biology and medicine it offers promising perspectives for mathematicians, physicists, and theoretically interested biologists. Many new institutes, curricula, and research networks in systems biology and medicine manifest this boom. However, a boom raises suspicion and might offer only short-term perspectives. So the question is: is there also a long-term perspective?

First of all, mathematical biology is nothing new! There are Baltic, British, French, German, Italian, Spanish, and Russian roots ranging back to the end of the 19th century. Mathematical biology was initially triggered by enormous amounts of "data" arising from new observations (e.g. from expeditions into colonial countries) and new experimental techniques. The famous Mendel experiments and a fertile communication between experimental biologists and applied mathematicians in the 1930's marked the beginnings of population genetics and created a nucleus for mathematical biology.

Responsible for the recently experienced boom of systems biology is again a data jungle, now called big data and predominantly stemming from new molecular biological methods together with the concurrent rapid development of high performance computing capabilities. As the 20th century was the "century of physics", the 21st century will be the "century of biology and medicine", and the essential developments will

only be possible from strong support by mathematical and computational methods at the data acquisition, representation and interpretation level. Together with specialists from related disciplines as bioinformatics and biophysics, mathematical methods are applied to more and more biological systems and medical problems. Rather new and hot applications are in the fields of bioengineering, biological regeneration, immunology, infectious diseases or personalised tumour therapy. Besides the need for developing models for particular biological and medical problems, mathematical biology helps to extract general principles of complex systems. A better understanding of such principles can be further exploited as bio-inspired solutions for technological applications.

(Continued on the next page)

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Newsletter #17

Press releases

The ICMAT regularly sends press releases to a broad range of journalists specializing in science and education, with the aim of keeping the general public informed about the activities of the Institute. In 2018, 22 press releases were prepared and issued, covering a wide variety of topics: from reports on new scientific results to information about events, the award of grants and prizes, etc. All these press releases are available on the ICMAT website.

"Café y Teoremas", *El País*

"Coffee and Theorems" is a weekly mainstream press item coordinated by the ICMAT and published in the section entitled Materia of the El País daily newspaper (ciencia de elpais.es.) This space is devoted to mathematics and the context in which mathematics is set, where researchers, members and collaborators of the centre give an account of the latest developments in the discipline, as well as sharing the points of confluence between mathematics and other social and cultural expressions. They also highlight those to whom we owe these developments and how they transformed them from coffee into theorems. 39 articles appeared in 2018, among which was one published every month on mathematical biology (since 2018 was the year dedicated to this interdisciplinary field). The full list of articles is as follows:

1. "The mathematician who invented complex numbers". By Manuel de León (CSIC-ICMAT) and Ágata Timón (ICMAT)

2. "The hard road from micro- to macro-scopic". By David Pérez García (UCM-ICMAT).

3. "A mathematician with four life sentences". By Manuel de León (CSIC-ICMAT).

4. "What mathematics can learn from ants". By Marco Fontelos (CSIC-ICMAT) and María Vela (UCM).

5. "Death of Alan Baker, the explorer of transcendental numbers". By Juanjo Rué (Universidad Politécnica de Cataluña) and Ágata Timón (ICMAT).

6. "David Hilbert and the defence of mathematical rigour". Por Fernando Bombal (UCM).

7. "Pi Day: algorithms lead to new values of the number π". By Jesús Guillera (Universidad de Zaragoza).

8. "Multimedia art to express the ineffable in mathematics". By Pierre Berger (CNRS and Universidad de Paris 13) and Ágata A. Timón (ICMAT).

9. "The mathematics that Stephen Hawking left us with". By Ernesto Nungesser (ICMAT) and Ágata A. Timón (ICMAT).

10. "Mathematics for deciphering the evolution of the species". By Marta Casanellas (Universitat Politècnica de Catalunya).

11. "Giordano Bruno, passionate hunter of the truth". By Franco Ventriglia (University 'Federico II' of Naples).

12. "An amateur makes the first breakthrough in a famous combinatory problem in the last 60 years". By Alberto Márquez (Universidad de Sevilla) and Ágata Timón (ICMAT).

13. "Polynomials against quantum computers". By Ignacio Luengo (ICMAT-UCM).

14. "The brilliant brother of Simone Weil". By David Fernández (University of Bielefeld) and Ágata Timón (ICMAT).

15. "The common mathematical structure of noise, the diffusion of oxygen and LED lights". By Marcel Filoche (École Polytechnique).

16. "The three bullfighters of mathematics: that's the KAM theory". By Cristina Sardón Muñoz and Víctor Arnaiz Solórzano (ICMAT).

17. "The mathematician who studied the free frontiers". By Antonio Córdoba (ICMAT-UAM).

18. "¿How has mathematics become the most popular university degree course?". By Ángela Capel, Jesús Ocáriz, Roi Naveiro, Patricia Contreras and Ágata Timón (ICMAT).

19. "In memory of Maryam Mirzakhani, the explorer of surfaces". By Eva Miranda (Universitat Politècnica de Catalunya – ICMAT).

20. "Mathematical models for understanding how the immune system works". By Carmen Molina-París (Leeds University) and Ágata Timón (ICMAT).

21. "Our mathematics could be radically different". Por Patricia Contreras (UCM-ICMAT) y Ágata Timón (ICMAT).

22. "When the Fields Medals fail to recognize the best". By David Fernández (University of Bielefeld) and Ágata Timón (ICMAT).

23. "Where to go in summer to think". By Ágata Timón (ICMAT).

24. "The Ukrainian female mathematician who could have won a Fields Medal". By Eva Miranda (Universitat Politècnica de Catalunya – ICMAT).

25. "Katherine Johnson, the calculator that helped 'Apollo 11' to reach the moon". By Mª Ángeles García Ferrero (Max Planck Institute of Mathematics, Leipzig) and Laura Moreno Iraola (ICMAT).

26. "¿Do cells speak the language of mathematics?". By Isabel Guerrero (Severo Ochoa Centre of Molecular Biology, Universidad Autónoma de Madrid) and Juan Soler (Universidad de Granada).

27. "Mersenne and the machines that make prime numbers". By José Granados (UAM-ICMAT).

28. "This is how future stars of international mathematics are formed". By Eugenio Hernández (UAM).

29. "The tape with only one side". By Marta Macho (EHU-UPV).

30. "Mathematics for understanding the brain". By Ágata Timón (ICMAT).

31. "Mathematics that describe the shape of the coast". By Fernando Chamizo and Ágata Timón (ICMAT).

32. "The mathematics behind the detection of malware". By Alberto Redondo (ICMAT).

33. "The discovery of "Hawking points' that could be the footprints of former universes". By Ernesto Nungesser and Ágata Timón (ICMAT).

34. "The mathematics of phenomena that are repeated". Por Eva Miranda (Universitat Politècnica de Catalunya – ICMAT).

35. "Why I study the seventh dimension". By Jason Lotay (University College London).

36. "The indomitable imagination of the first female programmer in history". By Mª Isabel González Vasco (URJC).

37. "Mathemetics to stop HIV infection". By Irina Gainova, Larisa Beilina, Jordi Argilaguet, Andreas Meyerhans and Gennady Bocharov.

38. "Mathematics for protecting democracy". By Juan José Marín (ICMAT) and Patricia Ruiz Guevara

39. "An unknown curious fact about the golden ratio". Byr Andrés Navas (Universidad de Santiago de Chile and Universidad Nacional Autónoma de México).

News

The ICMAT regularly publishes news on its website about the scientific and outreach activity conducted at the Centre. In 2018, 37 news items were published, including those issued to the media as press releases.

The Institute Blog

The ICMAT blog provides a platform on the website for the day-to-day activity at the Centre as well as for sharing information regarding mathematics and the mathematical community. Nine articles appeared on this blog in 2018.

Collaboration with the media

The ICMAT collaborates regularly with the leading media outlets in Spain. Among the many collaborations conducted by ICMAT members in 2018, some of the most noteworthy are listed below:

- "The mathematics of Ursula K. Le Guin", Manuel de León (ICMAT) and Ágata Timón (ICMAT), *El Cultural*
- "The mathematical revolution began on a sheep farm", David Martín de Diego (ICMAT) and Ágata Timón, *OpenMind*
- "How the dream of an infallible mathematics ended (and modern computation was born)", Nelo Maestre (Divermates) and Ágata Timón, *OpenMind*
- "Emmy Noether and mathematics for understanding Relativity", Marco Castrillón (ICMAT) and Ágata Timón, *OpenMind*
- "Discover the hidden order in chaos", Makrina Agaoglou and Ágata Timón, *OpenMind.*

Social networks

The ICMAT maintains active profiles on the main social networks. The number of followers as of December, 2018, is shown below:

- Facebook: 20,630 followers
- Twitter: 21,442 followers
- Instagram: 1,400 followers
- YouTube: 798 subscribers; 27,077 views

An average of three different contents are usually posted every day on Facebook and Twitter, dealing with current mathematical issues about both the ICMAT occasionally and in general, and exclusively about the ICMAT on Instagram. Videos made by the ICMAT are uploaded onto Youtube.

Outreach activities 2018

4º ESO + EMPRESA

The ICMAT participates annually in the Community of Madrid "4ESO+Empresa" Programme, which offers educational stays with companies and research centres for young students. Over a period of three days, the pupils are introduced to the day-to-day activities of the Institute for the purpose making them aware of mathematical research as a viable career choice, as well as showing them the daily work of mathematical scientists and the path to follow to arrive at that point. In the 2018 edition, the ICMAT hosted 30 pupils of both sexes from schools in Madrid, such as the IES San Isidro (Madrid), the IES Margarita Salas (Majadahonda), the IES Nicolás Copérnico (Parla), the IES Laguna de Joatzel (Getafe) and the IES Antares (Rivas Vaciamadrid) secondary schools, among others. ICMAT researchers and personnel participated by giving different workshops and talks.

4º ESO + Empresa

Matemathics at the Residencia

"Mathematics at the Residencia" consists of a series of talks given by internationally recognized popularizers of mathematics. It is organized by the ICMAT in collaboration with the CSIC Vice-Presidency of Organization and Scientific Culture, and the Residencia de Estudiantes in Madrid. Two annual conferences are normally held and take place at the Residencia's own assembly hall.

The following talks were given in 2018:

"The number that computers could never calculate"

Speaker: Eduardo Sáenz de Cabezón (University of La Rioja)

Date: March 22nd

Place: Residencia de Estudiantes (Madrid)

Eduardo Sáenz de Cabezón, Mathematics at the Residencia

"The importance of being inaccurate in mathematics"

Speaker: Mickaël Launay (author of "The Great Novel of Mathematics")
Date: November 29th
Place: Residencia de Estudiantes (Madrid)

Mickaël Launay, Mathematics at the Residencia

Science in action

Science in Action is an annual competition that seeks innovative and educational outreach ideas to bring science into closer contact with the public at large. The entries chosen from the first phase (remote) then present their proposals live in a final that becomes a great itinerant scientific fair, held each year in a different Spanish municipality. The ICMAT participates with other scientific institutions in the organization. In addition, in 2018, Laura Iraola attended the 19th fair in the capacity of judge and Antonio Córdoba presented the ICMAT Prize.

Image: ICMAT

CeA 2018

Science week

The Science and Technology Week is one of the leading events for the social communication of science and technology to be held in Spain. The ICMAT participates annually in this initiative by programming mathematical outreach talks and workshops for all sectors of society. The main aim of these activities is to increase the social perception of mathematics by showing surprising, unexpected, entertaining and awareness-raising facets of mathematics for the public at large.

In 2018, the Institute organized two activities for students in collaboration with the Pablo Iglesias Cultural Centre in Alcobendas (Madrid):

"Maths gymkhana"

Coordinators: Ángela Capel and Jesús Ocáriz (ICMAT)

Date: November 5th

Place: C. C. Pablo Iglesias (Alcobendas, Madrid)

Target audience: 3rd & 4th year secondary school pupils

Image: ICMAT

Maths gymkhana

Talk: "I count every day, with or without company"

Speaker: Luis Rández (University of Zaragoza, University Institute of Mathematics and Applications)

Date: November 6th

Place: C. C. Pablo Iglesias (Alcobendas, Madrid)

Target audience: Baccalaureate science students

Image: ICMAT

Luis Rández during his talk

"It's A Risky Life!"

In January, 2018, the last episode in the outreach series "It's a risky life!" was made public. This initiative is financed by the AXA Research Fund and developed by the ICMAT. The videos were produced and directed by Filmociencia, a scientific audiovisual service.

The series was first launched on the Institute's Youtube channel in December, 2016. It consists of eight episodes each lasting about two minutes, with versions in Spanish and English. Furthermore, a challenge concerning the misunderstandings about risk perception are posed at the end of each video. The winner was presented with an Aisoy programmable social robot.


Image: ICMAT

"Its a risky life"

Mathematical Revolution

First launched in November, 2018, "Mathematical Revolutions" is a series of animated videos in which moments in the history of mathematics that have changed the shape of civilization are narrated. The videos also include the people who brought

about those changes. Each episode concludes by proposing an activity about the mathematical concepts introduced in the classroom to be worked on creatively and entertainingly. The project is funded by the CSIC General Foundation (FGCSIC) and produced by the ICMAT Scientific Culture Unit, Divermates and the animator Irene López. In 2018, two episodes (one on Theano and the Pythagoreans, and the other on the decimal system) were made available on the ICMAT Youtube channel.
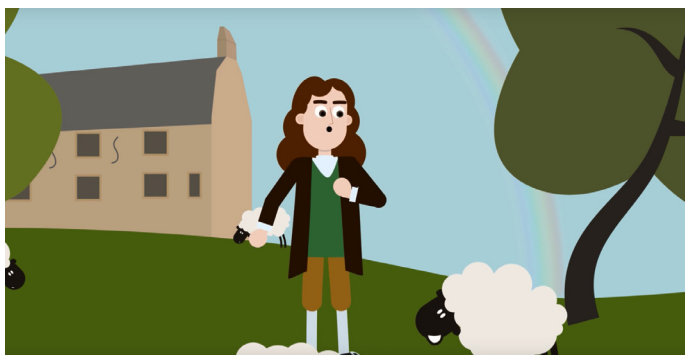
Mathematical Revolution (1)
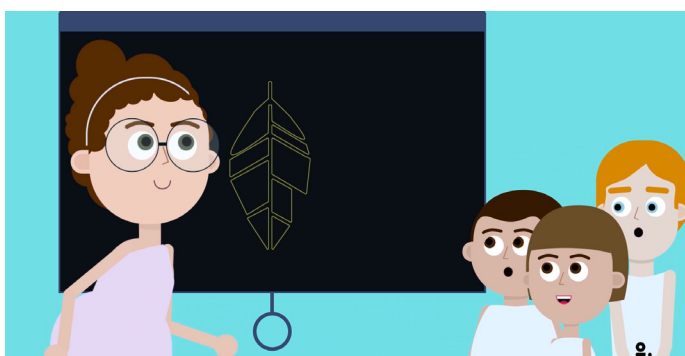
Mathematical Revolution (2)

The "Miradas Matemáticas" collection

"Miradas Matemáticas" consists of a series of books launched in 2017 and combining mathematical outreach and didactics, designed to bring research closer to secondary school and baccalaureate teachers. The books in the collection are produced by the ICMAT, the Spanish Federation of Mathematics Teachers (FESPM) and the publisher *Los Libros de la Catarata*.

The following volumes were published in 2018:
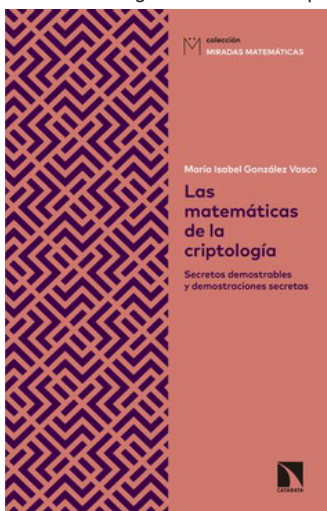
The mathematics of cryptology

"The mathematics of cryptology"

María Isabel González Vasco (Universidad Rey Juan Carlos). July, 2018.

"The mathematics of art"

Julio Rodríguez Taboada and Pilar García Agra (FESPM). September, 2018.

"The mathematics of daily life"

Miquel Albertí Palmer (FESPM). November, 2018.

The mathematics of art

The mathematics of daily life

"Numbers Before Christmas"

"Numbers before Christmas" is a mini-course that was first organized by the ICMAT on December 17th and 18th, 2018. It was directed by ICMAT postdoctoral researchers David Alfaya and Daniele Casazza. The course focuses on the mathematical basis of elliptic curves and applications to cryptography. The dynamics of the sessions alternated theoretical exposition with practical exercises to be completed by teamwork and in direct contact with the researchers themselves, who acted as "mentors". In addition, IC-MAT Deputy Director, Chema Martell, gave a presentation on the work of the Institute and on a career in mathematical research.

The main aim of this mini-course was to introduce some aspects of advanced mathematics to those second-year baccalaureate science students interested in the subject.

Image: ICMAT
"Numbers before Christmas"

School visits

The ICMAT regularly opens its doors to school groups of different educational levels in order to show them at first-hand how mathematical research is conducted.

Collaborations with other institutes

Talk: "Bees and mathematics"
Speaker: David Martín de Diego (ICMAT)
Date: February 19th, 2018
Place: ICMAT
Cycle: Community of Madrid teacher training course

Presentation "My favourite female scientist"
Speaker: Ágata Timón (ICMAT)
Date: March 13th, 2018
Place: Universidad Nebrija (Campus de Princesa, Madrid)
Cycle: Day before Pi

Talk: "Mathematics in spite of everything"
Speaker: Ágata Timón (ICMAT)
Date: March 14th, 2018
Place: Basque Center for Applied Mathematics (BCAM)
Cycle: BCAM-Naukas Pi Day

Preview colloquium "The Warning"
Speaker: Alberto Enciso (ICMAT)
Date: March 21st, 2018
Place: Palacio de la Prensa (Madrid)
Cycle: Colloquium after the preview of the film "The Warning"

Talk: "Fractals and mathematics"
Speaker: Cristina Sardón (ICMAT)
Date: March 23rd, 2018
Place: Liceo Francés Molière
Cycle: Liceo Mathematics Week

Graphic communication

The ICMAT Communication Office is responsible for preparing posters for the different activities that take place at the Centre in order to assist and facilitate their publicity and diffusion. Almost 200 of such posters were designed in 2018.
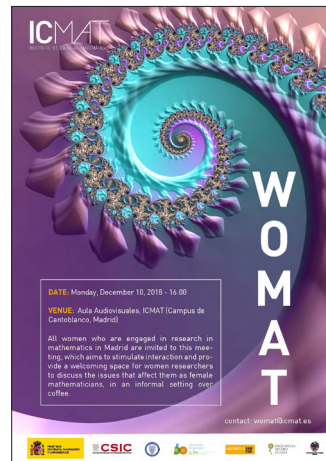
WOMAT Poster
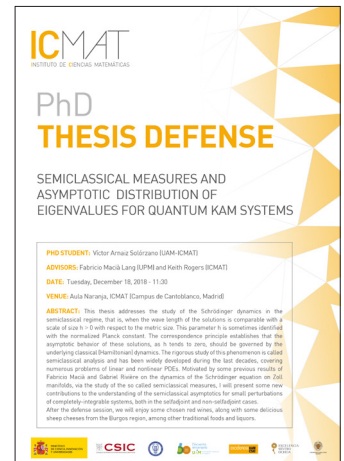
Thesis defense poster

BYMAT poster

Trimester poster
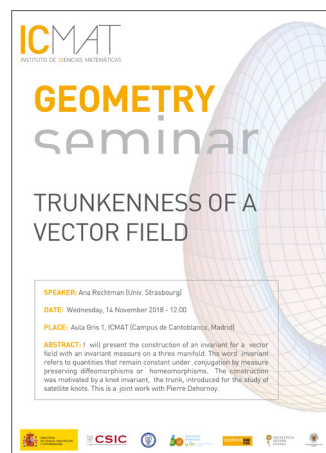
Geometry seminar poster
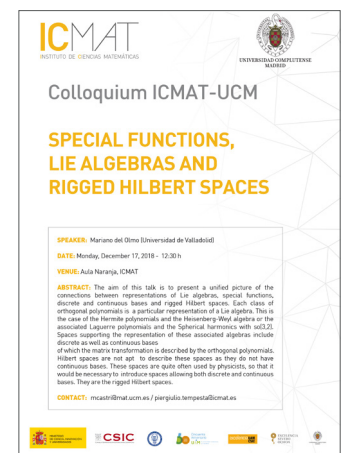
Colloquium ICMAT-UCM poster

12. Transfer activities

The ICMAT conducts the transfer of mathematical knowledge to industry and society. The science of excellence prac-tised by the researchers at the centre provides innovative knowledge that translates into solutions for business, industry and public administrations.

The Institute undertakes projects that require complex mathematical models, defining objectives in close col-laboration with companies. In the main, the areas in which ICMAT researchers have transferred innovative solu-tions are as follows: Data science, risk analysis, machine learning and geophysical fluid mechanics, especially in relation to cyber security, insurance, the analysis of oceanic and atmospheric flows, and the development of mathematical tools for new marine technologies.

In 2018, members of the ICMAT signed contracts directly with companies (mainly for advisory and consultancy tasks), as well as launching projects funded through public calls, both national and international, which also involve the participation of companies.

The AXA Research Foundation sponsors the AXA Chair in Adver-sarial Risk Analysis, directed by David Ríos Insua (01/09/2014 - 31/08/2022). Ríos collaborates in different mathematical knowl-edge-transfer projects, and in September, 2018, he contracted a technician in knowledge-transfer to provide him with support in his tasks.

Collaboration in the sector has taken different forms:

- Assessment and scientific evaluation. In early 2017, the DataLab (https://datalab.icmat.es) was launched, an office consisting of members of the SPOR research group, which provides statistical services to other CSIC institutes and companies, including for example the Institute of Medical Chemistry and the Salud Carlos III Institute in Madrid.

- Particlpation in European collaborative projects (FP7 / H2020). In particular, up to the end of 2018, the ICMAT partic-ipated in two large consortiums alongside different compa-nies, with funding from the EU that amounted to 427,565.00 €. The following projects were developed:

  1. CYBECO (https://www.cybeco.eu/): On May 1st, 2017, a project belonging to the H2020 societal challenges in cy-ber security and cyber insurance was begun in which the ICMAT participates as a partner and scientific director.

  2. IMPRESSIVE (Integrated marine pollution risk assess-ment and emergency management in ports and coastal environments) began in December, 2018.

- Development of R+D projects through contracts and projects backed by national funds with the involvement of companies. Five R+D contracts and projects were implemented up until December, 2018. They include a contract to evaluate suppli-er cyber risks and network monitoring, and another recently for geoprofiling. Furthermore, in early 2018 a project fund-ed by the 2017 Collaboration Challenges National Plan for developing a platform to rate cyber security was set in mo-tion. The funding received for R+D projects with companies amounted to 296,341.25 €

- Training courses on demand.

Other activities

- Presence at different relevant knowledge-transfer events, such as the "PT-Math-In" meeting, which was held in Lisbon in October, 2018.

All the knowledge-transfer projects (not only with companies, but also in other contexts) active throughout 2018 are given below:

- 1,176,000.00 €. Period of execution: 01/09/2014 - 31/08/2022.

- Technological support contract: "Innovative Marketing plat-form for proximity and payment at point of purchase, based on Bluetooth LE technology, which is communicated to the user individually in real time". PR: David Ríos Insua. Funder: SIEM, Software & Security Services, SL. Amount: 30,000.00 €. Period of execution: 23/10/2018 - 31/12/2018

- Dynamical systems and geophysical flows: new perspectives and applications. PR: Ana María Mancho. Funder: USA Office of Naval Research. Amount: 70,000.00 €. Period of execu-tion: 30/09/2017 - 30/09/2019.

- SecRating: Platform for the calculation of cyber security rat-ings and management of supplier cyber risk. PR: David Ríos Insua. Funder: Ministerio de Ciencia, Innovación y Universi-dades (MICINN). Amount: 231,844.00 €. Period of execution: 01/01/2018 - 31/12/2019.

- Supporting Cyberinsurance from a Behavioural Choice Perspective. PR: David Ríos Insua. Funder: CE. Amount: 251,250.00 €. Period of execution: 01/05/2017 - 30/04/2019.

- Integrated Marine Pollution Risk assessment and Emergen-cy management Support Service In ports and coastal en-VironmEnts. PR: Ana Maria Mancho. Funder: CE. Amount: 176,315.00 €. Period of execution: 01/12/2018 - 31/05/2021.

- Advances in risk management for security. PR: David Ríos Insua. Funder: Ministry of Science, Innovation and Univer-sities (MICINN). Amount: 26,600.00 €. Period of execution: 01/01/2018 - 31/12/2020.

Over recent years, scientific institutions have become increasingly conscious of the inequality existing between men and women in the research world, and thus for the need to remedy this situation. The facts are clear; as is evident in the document "Women scientists in figures 2017", coordinated by Ana Puy Rodríguez from the Women and Science Unit, and published by the Spanish Ministry for Science, Innovation and Universities, "the presence of women in senior management positions in universities and Public Research Bodies (OPIs) is still at a very low level. The glass ceiling in research careers is still in place, since only 21% of university professors are women and only 25% of research professors…"

These figures show an even greater imbalance in mathematics. Furthermore, the situation in mathematical research centres like the Institute of Mathematical Sciences (ICMAT) is even more dramatic. While in universities the percentage of female professors ranges from 5% in fields such as Mathematical Analysis to 19% in areas like Statistics, the percentage of women research professors at the ICMAT is precisely 0% percent. However, the problem is not confined to the highest posts, since there also exists a significant gender gap among those on the first rungs of a research career in mathematics. This is not just an issue that is specific to the ICMAT, but indeed is repeated in centres throughout Europe, where the situation is often even more unbalanced.

But far from being rectified, the situation continues to get worse as the years go by, in parallel with the increase in prestige of those who pursue a professional career in mathematics. Indeed, the number of women who set out to do a degree or a PhD in mathematics is actually falling.

In the light of these figures (and others we shall mention later), it is time to ask ourselves a few questions: Why don't women chose mathematical research as a professional career? What makes mathematics different from other sciences? What image do students of a research career in mathematics have? How is this message reproduced or supported? How can it be reversed? Why don't women remain in a research career?

The ICMAT made a response to these questions in 2016 by setting up a Gender Commission with the task of designing and executing a Gender Action Plan, included in the Severo Ochoa Excellence Programme awarded to the Institute by the then MINEICO for the 2015-2019 period. The creation of this Commission was driven by ICMAT and Severo Ochoa management teams, which reflects the institutional commitment of the ICMAT to issues of gender. The commission is composed of Ana Bravo (Chair), Ágata Timón (coordinator), Laura Moreno Iraola, Eva Gallardo, Marta Macho-Stadler, Edith Padrón, David Martín de Diego and Javier Aramayona.

Two years later, in late 2018, two women researchers at the ICMAT, Makrina Agaoglou and Patricia Contreras, wanted to go even further than the ICMAT framework. In collaboration with the Gender Commission, they created the WOMAT association of women mathematicians with its base in Madrid. The aim of the association is "to pave the way towards a more inclusive mathematical community". To that end, they organize a monthly meeting for women devoted to mathematical research, as well as making and distributing posters to stimulate thought about gender inequality, and have also held day sessions and seminars on the issue, among other initiatives.

In addition, activities organized by the ICMAT Gender Commission focus on fostering vocations at an early stage of education (in primary and secondary schools), as well the consolidation of the first stages in the careers of young researchers to encourage them to remain in the research profession.

A list of the measures adopted by the ICMAT to address these matters throughout 2018 is given below:

Analysis of the situation

In 2018, a breakdown of the data concerning all the ICMAT personnel, of the calls issued by the centre and the projects obtained, was conducted, contextualized with the situation in other institutions. In Spain, the number of women holding positions in mathematical research is much lower than in other areas, both in universities and in the CSIC. In the universities, the accentuation of the gender gap in mathematics is less than in the CSIC. In the first case, one moves from a percentage of 39.9% to 35% in mathematics, while in the case of the CSIC, it falls from a figure of 35.7% of women belonging to the research and public servant to 6.98% at the ICMAT.

This situation of greater gender inequality in the field of mathematics can be found at all the stages of a research career. While 41.9% of the research personnel in training at the CSIC are women and 49.8% at the universities, in the field of mathematics this figure drops to 28% at the universities. In the case of the ICMAT, 25% of the theses presented over the last eight years have been by women, but in 2019 this figure is 14.63%. 43.6% of postdoctoral researchers at the CSIC are women, and at the ICMAT this figure is 19.44%. The 35.7% of women forming the research and public servant personnel at the Institution drops to 6.98% at the ICMAT itself. The overall data of the ICMAT research personnel is summarized in the table below:

	Total	Men	Women	% of women
2011	103	80	23	22%
2012	99	79	20	20%
2013	127	103	24	19%
2014	142	117	25	18%
2015	154	125	29	19%
2016	146	124	22	15%
2017	148	125	23	16%
2018	145	126	19	13%

Not only is the low number of women striking, but also that it has fallen since 2011. Differentiating between the three member types belonging to the ICMAT (Faculty, Postdocs and PhD students), one may observe that the drop in the number of women is mainly due to the reduction in women PhD students:

PhD students
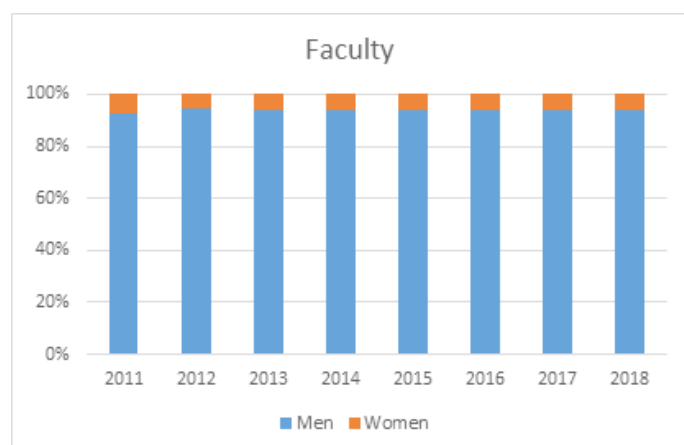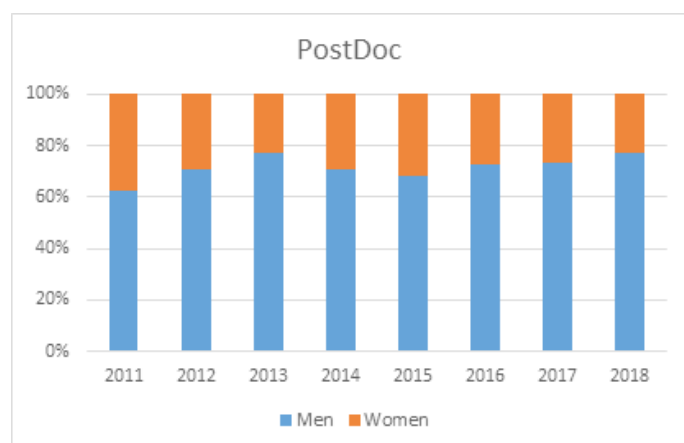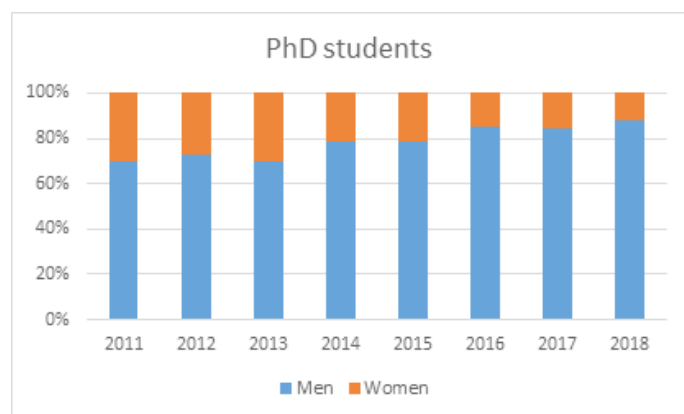
PostDoc

Faculty

The current figures are as follows:

Research personnell	Women	Men
Faculty	3	40
Postdocs	7	29
PhD students	4	38
Associated members	3	5

It is precisely because of these figures that we have concentrated our activity on the early stages of the research career and in encouraging a sense of vocation.

If we observe the distribution of the members according to sex in the ICMAT research groups including permanent members, postdocs and predocs), we find the following situation:

Group	Women	Men
Mathematical analysis group	1 [4,76%]	20
Differential equations and applications group	3 [18,75%]	13
Statistics, probability and operation research group	2 [15,38%]	11
Algebraic geometry and mathematical physics group	1 [9,09%]	10
Differential geometry and geometric mechanics group	1 [5,26%]	18
Quantum information mathematics group	4 [18,18%]	18
Mathematical modelling and simulation group	3 [75%]	1
Group theory	2 [28,57%]	5
Number theory	3 [37,5%]	5

Only one of these groups has a woman as its head, which represents 11.11% of the total number of group heads at the ICMAT.

Data regarding currently active research projects at the ICMAT are as follows:

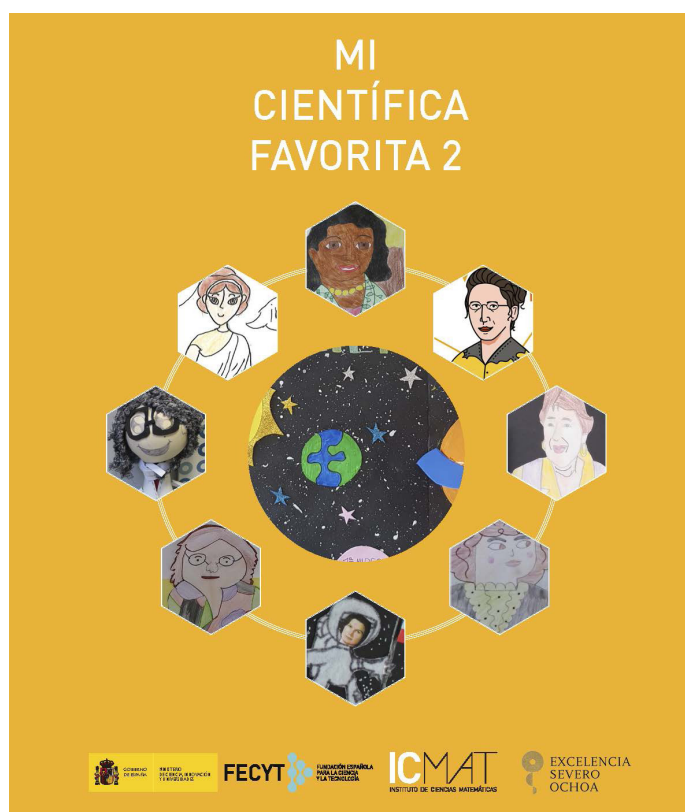| Active projects	PR Woman	PR Man
National plan	1	22
European funding	1	7
International non-European funding	1	0

The percentage of women (applicants and chosen) in calls issued by the ICMAT is given below:

ICMAT CALLS	Applications	Women	Chosen	Women
INTRO Grants				
2016	78	19	21	6
2017	48	12	20	2
2018	45	10	25	4
2019	87	17	25	1
MASTER Grants				
2016	10	3	5	2
2017	14	3	7	1
2018	13	2	7	2
POSTDOC Applications of Interest				
2016	144	21	6	1
2017	96	16	4	1
2018	67	13	10	0
Predoctoral Grants				
2016	17	5	6	1
2017	15	1	7	1
2018	28	4	7	1
Juan de la Cierva Appointment Application Grants				
2016	3	0	1	0
2017	2	0	0	0
2018	4	2		
Juan de la Cierva Training Application Grants				
2016	2	1	2	1
2017	6	1	0	0
2018	3	1		

"My favourite woman scientist"

"My favourite woman scientist" is an activity aimed at 5th and 6th year primary pupils from all over Spain. Its purpose is to provide role models that break with gender stereotypes foster scientific vocation in young girls and boys. Its first phase consists of a competition in which the pupils delve into the life and work of women scientists and then complete a graphic assignment based on what they have learnt. Schools submit a preliminary selection of the works and a panel composed of members of the ICMAT Gender Commission make a final choice of the entries, which are subsequently published in a book about female scientists. These entries are then complemented with written work in which the scientific contributions of the women researchers are presented informatively, as well as curious facts about their lives and key moments in their careers. The resulting catalogue is a science outreach work for fostering gender equality and scientific vocation. It is distributed in hard copy to the participating schools and is also available for download on the ICMAT website.

To date, three such editions have appeared in the 2016/2017; 2017/2018 and 2018/2019 (incomplete) school years. The first two editions arising from this project have been funded by the Spanish Foundation for Science and Technology (FECYT) and the third by the ICMAT itself.

WOMAT meeting

February 11th commemoration

Since 2017, the ICMAT has joined in celebrating International Women's Day and International Day of Women and Girls in Science with different activities.

- **Workshop: "Women mathematicians".** UAM professor and member of the ICMAT Gender Commission, Angélica Benito, gave a workshop-talk for secondary school students, during which the work of women mathematicians was presented.

Workshop: "Women mathematicians"

- **Videos: 11 F.** In 2018, several videos were made to commemorate 11-Feb Women's Day. Each video features a woman mathematical researcher at different stages of her career. The videos narrate how these women came to choose a career in research, what they like most about their profession and the difficulties they have faced because of their gender. The videos were distributed in accordance with the profiles on the ICMAT social networks.

MI CIENTÍFICA FAVORITA 2

"My favourite woman scientist 2"

Womat meetings

WOMAT organizes a monthly meeting of women mathematicians from all stages and spheres of the profession. The aim is to "stimulate the communication and interaction among women engaged in mathematics in Madrid, as well as to provide a space for open discussion on any subject that affects this collective, from gender inequality and how to establish a more inclusive working environment to making career choices.

Ángela Capel
Investigadora predoctoral en el ICMAT
11F video

- **Other activities.** Also on February 11th, the Institute issues a communique and shares a photograph of the women who belong to the centre. The same photograph is subsequently published in all the communication actions carried out by the CSIC. The ICMAT also participated in a round-table discussion in 2018 organized by the *Fundación Madri+d* to commemorate Women's Day on February 11th.

11F Round table

"She Does Maths" (ICMAT Newsletter and Poster)

This is a permanent section of the ICMAT Newsletter (issued twice a year) featuring the portrait of a woman mathematician (preferably in the workplace) and a brief description of her research work. It can also be found on the "Women with Science" blog. On the basis of this section in the ICMAT Newsletter se A3-size posters were made and affixed to the doors of the science faculties and maths departments of the three Madrid universities of which the Institute forms part: the Autonomous University, the Complutense University and the Carlos III University.

SDM: Patricia Contreras

Collaboration with other institutions

- **"Science by women" programme. Women for Africa Foundation (MxA).** For four consecutive years, the ICMAT has participated in the Women for Africa Foundation's (MxA) "Science by women" programme, aimed at promoting the access of African women to science and technology; supporting them in their research careers; publicizing their achievements; stimulating their leadership in the international scientific community, and helping to strengthen the capability of the research groups in their countries of origin. Thanks to this project, the Institute welcomed Latifa Debbi (National Polytechnic School of Algiers, Algeria) between June and October, 2018.

Latifa Debbi

- **Participation in the "MatEsElla" mentoring programme.** Several researchers from the ICMAT are collaborating as mentors for degree students in mathematics, mainly women, in their final year of degree or master courses as part of the MatEsElla" programme, backed by the Royal Spanish Mathematical Society (RSME) and the EJE&CON (*Asociación Española de Ejecutiv@s y Consejer@s*). The objective of this initiative is to promote the scientific and business careers of degree and master students in order to narrow the gender gap in the academic and business spheres.

- **Cabildo de Tenerife Collaboration.** In July, 2018, 10 students from different secondary schools in Tenerife visited the IC-MAT, where they participated in a workshop with Ana Bravo as part of the METV (Tenerife Violeta Strategic Policy for Gender Equality) programme, aimed at fostering vocation in mathematics.

Ana Bravo with students from different secondary schools in Tenerife

- **Collaboration with the Royal Spanish Mathematical Society's Women and Mathematics Commission.** The ICMAT Gender Commission maintains a close collaboration with the RSME Women and Mathematics Commission. Indeed, several members of its counterpart at the ICMAT are also members of the RSME Commission; specifically, Ana Bravo and Eva Gallardo.

14. Funding and Expenses

Non-competitive public funding

Evolution of the total ICMAT funding since its creation, according to the four institutions of which it is composed (CSIC, UAM, UCM and UC3M), is shown in the following list.

2011	832,000 €
2012	810,000 €
2013	792,000 €
2014	792,000 €
2015	792,000 €
2016	370,278 €
2017	400,159 €

Arrears in payment to the ICMAT from the UCM since 2011, which are the cause of serious problems in the daily management of the institute.

Competitive Funding

National Plan

An increase in funding was sought from the National Plan for the first and second proposals submitted by the ICMAT for the Severo Ochoa Centers of Excellence programme.

Unfortunately, the delay in the 2012 call and the absence of a call in 2013 have led to serious difficulties in the fulfilment of the original plan. However, ICMAT researchers have obtained almost 2,000,000 € in subsidies through the National Research Plan, including those that were still in effect in 2012-15. This funding derives from the following projects:

Code	Project	PR	€	Final date
ERC2018-092824	"Evolucion singular de flujos incompresibles"	Ángel Castro	75,000	30-11-2019
EQC2018-005104-P	"Adquisición de equipamiento científico-tecnológico"	Ana M. Mancho	102,493	30-06-2020
RTC-2017-6593-7	"SecRating: Plataforma para el cálculo de ratings de ciberseguridad y gestión del ciber riesgo de proveedores"	David Rios	262,452	30-06-2020
MTM2017-85934-C3-1-P	"Análisis y geometría con aplicaciones a problemas inversos"	Keith Rogers	13,915	31-12-2021
MTM2017-85934-C3-2-P	"Cálculo de variaciones y geometría con aplicaciones a mecánica de medios continuos y problemas inversos"	Luis Guijarro y Daniel Faraco	69,454	31-12-2021
MTM2017-89423-P	"Singularities in free surface flows"	Marco Antonio Fontelos Lopez	28,677	31-12-2020
MTM2017-89976-P	"Formación de singularidades en fluidos incompresibles"	Diego Cordoba Gazolaz	51,425	31-12-2020
MTM2017-86875-C3-1-R	"Avances en gestión de riesgos para la seguridad"	David Rios Insua	32,186	31-12-2020
MTM2017-82690-P	"Invariantes asintóticos de grupos"	Andrei Jaikin	36,300	31-12-2020
MTM2017-83496-P	"Aritmética y análisis armónico"	Antonio Córdoba y Fernando Chamizo	23,353	31-12-2020
MTM2017-88385-P	"Métodos matemáticos en información cuántica"	Carlos Palazuelos	35,332	31-12-2020
MTM2017-84098-P	"Fundamentos matemáticos de las tecnologías de la información cuánticas: convexidad, muestreo y algebras de operadores"	Alberto Ibort	58,564	31-12-2020
MTM2016-76072-P	"Análisis geométrico y numérico de sistemas dinámicos y aplicaciones a la física matemática"	David Martin de Diego y Daniel Peralta	65,219	29-12-2019
MTM2016-79400-P	"Simetrías en geometría aritmética, algebraica y simplecita"	José Ignacio Burgos Gil y Francisco Presas	75,141	29-12-2019

Code	Project	PR	€	Final date
MTM2016-81048-P	"Geometría de ecuaciones acopladas y espacios de moduli"	Oscar García Prada	45,133	29-12-2019
MTM2016-75465-P	"Ecuaciones en derivadas parciales: dinámica asintótica y perturbaciones"	José María Arrieta y Anibal Rodriguez Bernal	52,272	29-12-2019
MTM2016-81700-ERC	"Análisis armónico cuántico"	Javier Parcet Hernandez	35,000	30-09-2018
MTM2016-80618-P	"Nonlinear partial differential equations and coupled systems of PDEs of second and higher order"	Eduardo Colorado Heras	15,972	29-12-2019
MTM2016-76868-C2-1-P	"Geometría, Topología, Álgebra y Criptografía en Singularidades y sus Aplicaciones"	Pedro Daniel González	90,750	29-12-2020
SEV-2015-0554	"Programa de Excelencia Severo Ochoa"	Diego Córdoba Gazolaz	4,000,000	31-12-2019
MTM2015-72876-EXP	"Topología Engel"	Francisco Presas Mata	18,150	30-04-2019
MTM2015-72907-EXP	"Juegos diferenciales estocasticos: rompiendo cincuenta años del paradigma"	Antonio Gomez Corral	30,250	30-04-2019
MTM2015- 68524-P	"Geometría algebraica y aritmética"	Orlando Villamayor	60,258	31-12-2018
MTM2015-65888-C4-02-P	"Orthogonality, Approximation Theory and applications in Mathematical Physics"	Guillermo López Lagomasino y Francisco Marcellán Español	58,564	31-12-2018
MTM2015-65825-P	"Análisis funcional no lineal y geométrico"	Daniel Azagra	126,929	31-12-2018

It is necessary to point out that the great difficulties involved in the management of subsidies and contracts due to the rigidity of CSIC and MINECO procedures. Greater flexibility is required from the CSIC centres for the handling of undertakings such as the Severo Ochoa project.

CSIC calls (I-Link and I-Coop)

These are the projects belonging to the CSIC obtained by ICMAT researchers:

Code	Project	PR	€	Final date
CSIC-I-LINK. I-LINK1107	"Geometry of gauge equation and string theory"	Oscar García Prada	27,000	1-1-2017 — 31-12-2018
CSIC-I-COOP. COOPB20265	"Lagrangian Analysis of WestAfrican Monsoon Features" Participating Institutions: CSIC, Polytechnic School of Dakar	A. M. Mancho y C. Niang	17,500	1-1-2017 — 31-12-2018

Regional programmes

ICMAT researchers also head projects funded through calls issued by the Community of Madrid:

Code	Project	PR	€	Final date
S2018/TCS-4342	"Quantum Information Technologies Madrid+ (QUITEMAD+-CM)"	Alberto Ibort y 100,000 UCM-MATHQ, y David Pérez	CAM contribution: project budget: 1,050,060€ ICMAT Budget: 200,000€ (100,000€)	1-1-2019 — 31-12-2022
IND2018/TIC-9901	"Grant from the Madrid Government for Industrial Doctorate." Researcher: Bruno	David Rios	64,000	

Code	Project	PR	€	Date
2016-T3/TIC-1897	"Grant from the Madrid Government for attracting research talent. Modality 3. Grant for the incorporation of visiting researchers" Visiting Researcher: Fabrizio Rugferi	David Ríos	25,000	01-01-2017 — 30-06-2017
S2013/ICE-2801	"Quantum Information Thechnologies in Madrid"	David Pérez	62,100	01-10-2014 — 30-09-2018

International funding

On an international level, the framework programmes of the European Union constitute the main source of funding for the ICMAT. Specifically, such funding derives from the following projects:

ERC and Marie Curie Grants:					
Code	Reference	Project	PR	EU Contribution [€]	Date
FP7-IDEAS-ERC- StG	335079	"Invariant manifolds in dynamical systems and PDE. Acronym: INVARIANT"	Daniel Peralta (StG)	1,260,041	01-01-2014 — 30-06-2019
FP7-IDEAS-ERC- CoG	615112	"Harmonic Analysis, Partial Differential Equations and Geometric Measure Theory." Acronym: HAPDEGMT	José M. Martell	1,429,790	01-01-2014 — 31-12-2019
	615655	"New methods and interactions in Singularity Theory and Beyond." Acronym: NMST	Javier Fernandez de Bobadilla	1,140,601	01-05-14 — 30-04-19
H2020-ERC-StG		"Geometric problems in PDEs with applications to fluid mechanics. Acronym: GEOFLUIDS"	Alberto Enciso Carrasco	1,256,375	01-03-2015 — 29-2-2020
H2020-ERC-CoG	648913	"Spectral gaps in interacting quantum systems." Acronym: GAPS	David Pérez-García	1,462,750	01-09-2015 — 31-08-2020
H2020-ERC-AdG	788250	"Non-local dynamics in incompressible fluids" Acronym: NONFLU	Diego Córdoba Gazolaz	1,779,369	01-09-2018 — 31-08-2023
MARIE CURIE FP7-IRSES	246981	"Indo European Collaboration on Moduli Spaces." Acronym: MODULI.	Oscar García Prada (CSIC team leader)	724,500 [ICMAT budget 245,700]	01-01-2014 — 31-12-2018
MARIE CURIE FP7-IEF y MARIE SKLODOWSKKA CURIE H2020-IF	745722	"Geometric and analytic aspects of isoparametric hypersurfaces." Acronym: ISOPARAMETRIC	Alberto Enciso Carrasco (Scientific in charge) y Miguel Domínguez Vázquez (experienced researcher)	158,121	16-04-2017 — 15-1-2019

H2020 Industrial Leadership Pillar					
Code	Reference	Project	PR	EU Contribution [€]	Date
H2020-SPACE-2018	821922	"Integrated Marine Pollution Risk assessment and Emergency management Support Service In ports and coastal enVironmEnts". Acronym: IMPRESSIVE	Ana Mª Mancho	1,913,701 [ICMAT Budget: 176,315]	01-12-2018 — 31-05-2021

H2020 Societal Challenges Pillar					
Code	Reference	Project	PR	EU Contribution [€]	Date
H2020- DS-SC7-2016	740920	"Supporting Cyberinsurance from a Behavioural Choice Perspective" Acronym: CYBECO	David Ríos Insua (PI in CSIC)	1,983,510 [ICMAT Budget: 251,250]	01-05-2017 — 30-04-2019
H2020-MG-2018	815003	"Building Acceptance and Trust in Autonomous Mobility" Acronym: Trustonomy	David Ríos Insua (PI in CSIC)	3,920,000 [ICMAT Budget: 206,500]	01-05-2019 — 30-04-2022

Other projects				
National Science Foundation				
Code	Project	PR	Budget [$]	Date
DMS-1901290	"Operator Algebras, Groups, and Applications to Quantum Information"	David Kerr (Texas A&M) y Fernando Lledó	36,000	21-12-2018 — 29-02-2020

Private funding					
Contract with the company SIEM, Software & Security Services, SL					
Code	Reference	Project	PR	Budget [€]	Date
H2020- DS-SC7-2016	191007	"Plataforma innovadora de Marketing de Proximidad y Pagos en el Punto de Venta, basada en tecnología Bluetooth LE, que se comunica con el usuario de forma personalizada, en tiempo real, en el momento justo de la decisión de compra y en sitio adecuado"	David Ríos Insua	30,000	23-10-2018 — 31-12-2018

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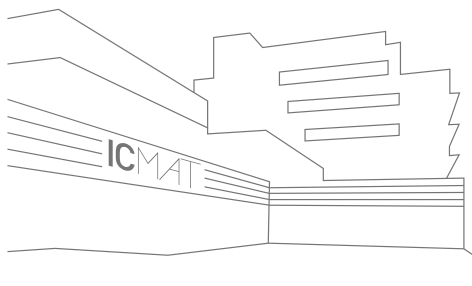
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