



AYUDAS RAMÓN Y CAJAL CONVOCATORIA 2019

Turno de acceso general

Nombre: RODRIGUEZ ALVAREZ, MARIA JOSE

Referencia: RYC2019-027534-I

Área Temática: Ciencias matemáticas

Correo Electrónico: mxrodriguez@bcamath.org

Título:

Semiparametric and nonparametric regression methods and their application in Medicine, Biology and Agriculture

Resumen de la Memoria:

My methodological research in Statistics covers three different, but related, areas: (a) Statistical evaluation of the diagnostic and/or prognostic value of clinical biomarkers, (b) Development of broadly applicable (and computationally efficient) estimation methods for flexible and complex regression models; and (c) Proposal of new statistical methods for the analysis of spatial and spatio-temporal processes. All my research has a strong multidisciplinary component with a special focus on Medical and Agricultural applications. Most of the statistical-methodological topics I have covered have been motivated by the need for analysing and understanding complex biological and health phenomena. Besides, the transfer of the new advances to other fields through user-friendly software constitutes an important fraction of my research.

I obtained my PhD in Mathematics at the USC in 2011. The topic of my PhD covered the development of new methodological approaches for the assessment of the diagnostic accuracy of clinical biomarkers in the presence of external information. Some of the obtained results represented the first attempts in the statistical literature to the inclusion of covariates in the ROC regression framework from a nonparametric perspective. As a consequence of my research in ROC curves, I have been invited to write two papers on the topic, for REVSTAT and Statistical Methods in Medical Research.

From 2008 to 2013 I worked as Biostatistician, first at the USC and then at the University Hospitals of Vigo and Santiago de Compostela, where I was responsible for providing statistical support and training to clinicians and basic researchers. My experience there taught me the importance of multidisciplinary research groups that make possible to understand and to address the research question from different angles. This is a process that enriches both the methodological research in Statistics and the scientific research in health-related fields.

During the last years, I have continued my research on diagnostic tests and started a new line on the statistical evaluation of time-to-event biomarkers. Besides, I initiated an independent research line on the proposal of general and computationally efficient estimation methods for flexible regression models. My aim here is to enable the use of these models in situations where they seem to be unfeasible due to the dimension of the problem. Meanwhile, I have been working on the proposal of new spatio-temporal methods in experimental research design. At this moment there is no standard way of analysing long-term data from continuously monitored populations of experimental units (e.g. plants). In this line, I seek new statistical methods that can extract, from the available data, the most relevant information on all aspects of (plant) growth and development. Although most of my research in Statistics is framed within the frequentist paradigm, I have recently initiated a new line of research on nonparametric Bayesian methods in combination with penalised splines. These lines of research have been carried out in collaboration with internationally-recognised researchers (to cite a few, Prof. P. Eilers, author of the seminal paper about penalised splines, Prof. T. Kneib, a well-known expert in flexible regression models and Prof. F. van Eeuwijk, an expert in quantitative genetics).

Resumen del Currículum Vitae:

I finished my undergraduate studies in Mathematics at the USC in 1999, and, from 2005 until 2007, I did a master's degree in Biostatistics (USC). I obtained my PhD in Mathematics at the USC in 2011.

My professional career started in the private sector. From 2001 until 2005, I worked in the IT sector, carrying out different roles. This experience gave me a strong background in programming and computation, which enriched my posterior research and research-related career. In 2006 I moved to the University, first as part-time Associate Lecturer at the UVIGO (2006–2007), and then as R & D project manager (Isabel Barreto's Competitive Grant Program, Xunta de Galicia) at the USC (2008–2009). My interest in multidisciplinary biomedical research led me to be awarded a competitive grant funded by the Instituto de Salud Carlos III. In 2010 I joined the University Hospital of Santiago de Compostela as Biostatistician, where I built a solid multidisciplinary career path. From 2013 until 2016, I had a competitive postdoctoral fellow contract (funded by the Xunta de Galicia) at the UVIGO. In 2016 I was awarded an IKERBASQUE Research Fellowship and joined BCAM (Basque Center for Applied Mathematics).

My methodological research in Statistics covers three different, but related, areas: (a) Statistical evaluation of the diagnostic and/or prognostic value of clinical biomarkers, (b) Development of broadly applicable (and computationally efficient) estimation methods for flexible and complex regression models; and (c) Proposal of new statistical methods for the analysis of spatial and spatio-temporal



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processes, with a special focus on experimental research design.

I have done several long-term research stays (in total more than 2 years) at different European Universities, where I have visited recognised researchers in Statistics (Prof. P. Eilers, Prof. T. Kneib and Prof. F. van Eeuwijk, among others).

As a result of my research both in statistical methodology and biomedical/agricultural applications, I have 34 publications in JCR journals (32 published + 2 accepted, 25 in Q1 and Q2), 3 of them upon invitation, 4 publications in peer-reviewed journals and 14 in conference proceedings and book chapters (1 upon invitation). I have 2 preprints submitted. These papers have received more than 620 citations according to the WOS. I currently have an h-factor of 13. I have also developed 10 R-packages, which are freely available from public repositories.

I have participated in 22 funded projects and contracts, 2 of them framed into the Spanish-German Integrated Actions Program. I have been the co-PI in 1 competitive-funded projects. Currently, I am the co-PI of a project funded by the AEI (MTM2017-82379-R). In 2016 I was awarded a project for young researchers (MTM2015-73670-JIN).

I have participated in more than 60 national and international conferences, 11 upon invitation. I have given 17 invited seminars in national and international institutions, and taught, upon invitation, several courses in Statistics.

I have co-directed a PhD in Mathematics and 6 Master s projects. I have supervised the statistical content of PhD dissertations and Master s projects in Medicine and mentored the training period of several students of the Master in Statistical Techniques (USC, UVIGO and UDC). I currently have under my supervision 1 PhD student and and 1 and 1 postdoctoral researcher.



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Nombre: GONZALEZ ALONSO, VICTOR
Referencia: RYC2019-026784-I
Área Temática: Ciencias matemáticas
Correo Electrónico: victor.gonzalez.alonso@gmail.com

Título:

Geometría algebraica: superficies fibradas, conjetura de Coleman-Oort, teoremas de Torelli e ideales multiplicadores

Resumen de la Memoria:

Mi campo de estudio es geometría algebraica, cubriendo diversos temas. Más concretamente, actualmente estoy trabajando en las siguientes áreas:

- Superficies fibradas y familias de curvas: en mi tesis doctoral demostré el caso genérico de la conjetura de Xiao sobre la irregularidad relativa de superficies fibradas. Recientemente he mejorado dicho resultado junto a L. Stoppino y S. Torelli, estimando el rango del sumando unitario plano del fibrado de Hodge de la fibración. Actualmente estoy trabajando con S. Torelli para obtener una nueva cota superior del rango del núcleo del campo de Higgs asociado a la fibración. Estas cuestiones están directamente relacionadas con la geometría de la aplicación de Torelli y la existencia de subvariedades totalmente geodésicas y de Shimura en el espacio de moduli de variedades abelianas complejas principalmente polarizadas.

- La conjetura de Xiao también puede ser propuesta sobre cuerpos de característica positiva, pero la existencia de diferentes nociones de irregularidad, la inexistencia (en general) de la descomposición de Hodge y otros fenómenos típicos de la característica positiva hacen imposible aplicar las mismas técnicas que en el caso complejo. Recientemente he iniciado una colaboración con R. Laface para resolver este problema.

- Teorema de Torelli infinitesimal para divisores en variedades abelianas: para obtener análogos del teorema de Torelli de curvas para variedades de dimensión más alta, habitualmente se considera primero el problema infinitesimal, que se reduce a la exhaustividad de una cierta aplicación de cup-producto. En el caso de divisores amplios en variedades abelianas, dicho problema está estrechamente relacionado con si la aplicación en el espacio proyectivo dada por el sistema lineal correspondiente es proyectivamente normal o no. Junto a mi estudiante de doctorado P. Bloss, estamos estudiando este caso, buscando condiciones suficientes para el teorema de Torelli en función de invariantes numéricos del divisor.

- Ideales multiplicadores en singularidades de superficie: En colaboración con M. Alberich-Carramiñana, J. Alvarez y F. Dachs, hemos estudiado el comportamiento de ideales multiplicadores y números de salto en singularidades racionales de superficie. Continuamos colaborando para estudiar otras propiedades y posibles generalizaciones a singularidades no racionales.

Resumen del Currículum Vitae:

Estudié la Licenciatura de Matemáticas (en el programa "Matemáticas+Complementos"), el Máster en Matemática Aplicada (TFM dirigido por M. Alberich) y el Doctorado en Matemática Aplicada (supervisado por M.A. Barja y J.C. Naranjo) en la Facultad de Matemáticas y Estadística de la Universidad Politécnica de Cataluña (UPC). Defendí la tesis "Hodge numbers of irregular varieties and fibrations" en julio de 2013.

Durante la Licenciatura escribí mis primeras publicaciones y disfruté de una "Beca de introducción a la investigación" del CSIC (con Javier Fernández de Bobadilla) y de una "Beca de colaboración" con Maria Alberich. Durante el doctorado realicé estancias en Chicago y Pavia.

Desde entonces trabajo en la "Leibniz Universität Hannover", 3 años en la "ERC-Starting Grant" de Matthias Schütt, y los últimos 4 años como "Junior Research Group Leader", con responsabilidades similares a un "Junior Professor" (en particular, la dirección de una tesis doctoral).

Mi investigación abarca varias áreas de la geometría algebraica, entre las que se encuentran:

- Variedades complejas irregulares: relaciones entre los números de Hodge de variedades irregulares complejas (compactas Kähler), geografía de superficies fibradas.

- Variaciones de estructuras de Hodge: familias de curvas complejas y geometría del lugar jacobiano en el espacio de moduli de variedades abelianas principalmente polarizadas.



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- Singularidades: curvas planas, superficies e ideales multiplicadores.
- Rectas en superficies.
- Automorfismos de superficies K3 (especialmente en característica positiva).

En total he publicado 13 artículos en revistas indexadas (5 en el primer cuartil, 6 en el segundo) y he sido conferenciante invitado en 10 congresos, así como asistente docente en la escuela de verano PRAGMATIC 2016. También he organizado diversas conferencias y pequeños "workshops", incluyendo las ediciones de 2010 y 2011 de "Géometrie Algébrique en Liberté - GAeL" y una escuela sobre Moduli y Condiciones de Estabilidad en Hannover en 2019.

Mi labor docente comenzó durante la Licenciatura como "Becario de apoyo a la docencia" y durante el doctorado impartiendo las clases de problemas de "Geometría Afín y Euclídea" y "Geometría Algebraica" en el Grado de Matemáticas. En Hannover he impartido clases de problemas ("Geometría Algebraica", "Variedades Tóricas") y también de teoría ("Teoría de Hodge", "Geometría Algebraica", "Matemáticas para Físicos"), encargándome también de las tareas organizativas asociadas.

He colaborado como vicelíder de la delegación española en un olimpiada matemática internacional (2014) y una iberoamericana (2010), así como en 4 ediciones del Barcelona Math Summer Camp impartiendo el minicurso de geometría.



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Nombre: CONDE ALONSO, JOSE MANUEL
Referencia: RYC2019-027910-I
Área Temática: Ciencias matemáticas
Correo Electrónico: joseconde1987@gmail.com

Título:

Análisis armónico en contextos generales: teoría de Calderón-Zygmund, probabilidad y álgebras de operadores

Resumen de la Memoria:

After studying a double major in Mathematics and Computer Science at Universidad Autónoma de Madrid (UAM) and a Master in Mathematics and applications in the same university, my research career started in 2011. I did my graduate studies at the Instituto de Ciencias Matemáticas (ICMAT) under the supervision of José García-Cuerva (UAM) and Javier Parcet (ICMAT). I graduated on May 25, 2015 with the highest degree of Sobresaliente cum laude. After that, between October 2015 and March 2017 I was a postdoctoral researcher at Universidad Aut ́onoma de Barcelona (UAB) in the research group lead by Xavier Tolsa (UAB-ICREA). I obtained the Vicent Caselles prize in 2016, a research prize awarded to mathematicians under 30 years of age. On April 2017 I joined the faculty of UAM as assistant professor (profesor ayudante doctor) that I suspended for 18 months to be a Tamarkin Assistant Professor at Brown University. On top of my two postdoctoral experiences, I have done several extended research visits in research centers both in Spain and abroad, including two at Wayne State University, one at Michigan State University, one at the University of Washington in St Louis and another at the University of Illinois at Urbana-Champaign. Recently, I have become the Principal Investigator of a project awarded with a grant (funding: 20700 euros) from the Madrid Regional Government and UAM. The duration of the project is two years and the grant funds a research team of four members, two of which are my own PhD students (one of them is still at the Master stage). I have participated in several other research projects, including two funded by the European Research Council. All the positions that I have held and the fellowships I have received (including the one I had the year in which I did my Master studies) have been obtained in competitive calls.

My research contribution in Mathematics can be generally framed in the area of Harmonic Analysis, although my work also includes results in functional analysis, classical and noncommutative probability, von Neumann algebras and noncommutative L_p spaces. The central topic of my PhD. dissertation was the study of Calderón-Zygmund operators, which appear naturally in many areas of Mathematics, including the analysis of PDE, fluid mechanics or quantum mechanics, among others. My work studies them in various contexts, from classical Euclidean spaces to probability spaces or von Neumann algebras. I have continued this line of work during later stages of my career, especially on the very recent trend of sparse domination, started after the proof of the A_2 theorem by Hytonen and the area were some of my best contributions so far lie. Another related line of research that I have pursued is the connection between martingale inequalities on abstract probability spaces and harmonic analysis on metric spaces equipped with very general measures, including nondoubling ones. During my stay at UAB I extended the scope of my work to other areas, like geometric measure theory. Finally, at Brown University I explored biparametric harmonic analysis, which is the context of one of my strongest and most recent contributions, among others. After starting at UAM, my research has been focused in noncommutative martingale inequalities, for which I have been awarded a grant as Principal Investigator.

Resumen del Currículum Vitae:

I obtained my PhD degree on May 2015. I have two postdoctoral experiences, each of 18 months of duration: one at Universitat Autònoma de Barcelona, in the research team led by X. Tolsa, and one at Brown University as Tamarkin Assistant Professor. After that, I have served as Profesor Ayudante Doctor as Universidad Autónoma de Madrid.

My work in Mathematics so far is distributed in 16 research papers, 12 of which have already been accepted or published in journals like Advances in Mathematics, Analysis & PDE, Mathematische Annalen or Proceedings of the American Mathematical Society, among others. According to the JCR database, 9 of the 12 belong to the first quartile (Q1). According to the Google Scholar database, my papers have received 190 citations (185 in the last 5 years) and an h-index of 5. My results are relevant and varied, and show my ability to collaborate with a variety of researchers and my independence, which is also confirmed by the fact that there are two graduate students pursuing their PhD projects under my supervision (graduation expected: 2023 and 2024, respectively). Indeed, only a small fraction of my papers have any of my supervisors as a coauthor. My results have achieved a high degree of visibility and recognition, and have helped to open new directions of research (as is shown by the high number of bibliographic citations of some of my papers). I have given invited talks in many seminars and conferences, both in Spain and abroad. For example, I was an invited speaker in the Satellite Conference in Harmonic Analysis of the 2018 ICM. My research was recognized with the Vicent Caselles prize in 2016; this is a research prize awarded to Spanish-based mathematicians under 30 years of age.

I am currently supervising the PhD training of two students, both at UAM: Ismael Cano (expected graduation: 2023) and Eduardo Tablate (completing master studies; expected graduation: 2024). I have participated in 2 projects funded by the European Research Council, 3



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projects funded by the Spanish government (MTM program) and I am currently the Principal Investigator of a grant from the Madrid regional government.

My research credentials are complemented by my teaching (for which I obtained the Brown Junior Faculty Fellow award in 2018), mentoring (Master and Bachelor thesis, in addition to PhD student training), and dissemination of knowledge (workshops for High School students, High School teacher training, and media appearances).



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Nombre: MANZANO PREGO, JOSE MIGUEL

Referencia: RYC2019-027658-I

Área Temática: Ciencias matemáticas

Correo Electrónico: manzanoprego@gmail.com

Título:

Superficies de curvatura media constante en espacios homogéneos

Resumen de la Memoria:

During the period leading to my PhD thesis and thereafter, I have been working mainly on problems related to constant mean curvature surfaces in different 3-manifolds sharing the property that they all admit Killing vector fields, specially in the particular case of homogeneous three-manifolds. This has led me to the elaboration of several research papers, alone or in collaboration with other researchers, which are currently published, submitted to peer-reviewed journals or in preparation.

The results obtained so far deal with the construction of constant mean curvature surfaces in product three-manifolds (horizontal Delaunay surfaces, compact embedded surfaces, saddle towers, Schwarz surfaces) and Killing submersions (Jenkins-Serrin problem), geometric estimates (curvature, area growth or height), overdetermined elliptic problems, classification results (isoparametric surfaces, totally umbilical surfaces), geometric correspondences (Lawson-type or Calabi-type), and stability of constant mean curvature surfaces. Additionally, I have dealt with other classes of surfaces such as parallel mean curvature surfaces in homogeneous four-manifolds, totally umbilical surfaces in homogeneous three-manifolds, and elastic surfaces (i.e., solutions to the Ou-Yang-Helfrich equation) in Euclidean space.

Throughout my career I have enjoyed 6 postdoctoral appointments (University of Roma III, Politecnico di Torino, King's College London, ICMAT, and University of Granada) covering a total of 9 years, as well as research stays for a total of 14 months. This has granted me the chance of collaborating with distinguished researchers (B. Coskunuzer, L. Hauswirth, H. Lee, E. Musso, B. Nelli, L. Nicolodi, J. Pérez, J. Plehnert, M. Rodríguez, R. Souam, G. Tinaglia, F. Torralbo, and J. Van der Veken). I have had excellent opportunities to attend and co-organise national and international research meetings on Differential Geometry, as well as to participate in some of them by presenting oral communications or posters. I have also co-organised the Geometry Seminar of University of Granada for 5 years. At the moment, I am co-supervising the PhD thesis of Jesús Castro-Infantes.

Resumen del Currículum Vitae:

During my research career, I have focused on the following aspects of Surface Theory:

- Constant mean curvature surfaces in homogeneous three-manifolds and three-dimensional Killing submersions: stability, overdetermined elliptic problems, surface correspondences (Calabi-type and Lawson-type), geometric estimates (height, area, curvature,...)
- Surfaces being critical points of the Calham-Helfrich functional (lipid membrane bilayers in Euclidean space).
- Totally umbilical surfaces and isoparametric surfaces in homogeneous three-manifolds.
- Parallel mean curvature surfaces in Thurston four-dimensional geometries.

SCIENTIFIC ACTIVITY

- 6 postdoctoral appointments for 9 years (Univ. Granada, Univ. Roma III, Politecnico Torino, King's College London, ICMAT, Univ. Granada).
- 17 research stays for a total of 14 months.
- 13 accepted papers in JCR journals.
- 3 accepted survey papers.
- 5 works in progress.
- 3 preprints.
- 13 collaborators.
- 41 oral communications in conferences, workshops, and seminars.
- 5 mini-courses.
- 4 posters, one of them awarded.
- Participation in 28 international conferences and workshops.
- Participation in 18 national conferences and workshops.
- Organising committee: 2 national and 5 international conferences.
- Scientific committee: 1 national and 1 international conferences.
- Co-organiser of the Geometry Seminar in the University of Granada for 5 years.
- 27 reviews for MathSciNet Mathematical Review Database.



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MEMBER OF RESEARCH GROUPS/TEAMS

- 2 foreign nationwide projects (Italy and UK governments).
- 5 Spanish nationwide projects.
- 3 regional projects and groups (Junta de Andalucía).
- 2 projects within an excellence research network (CEI-BioTIC Genil, Granada).
- 1 nationwide research network.
- 1 international research network.

TEACHING EXPERIENCE

- 550 teaching hours in the degrees of Mathematics, Optics, Physics, Environmental Sciences, Business Administration, Computer Science, and Industrial Engineering.
- 4 end-of-degree projects + 2 intro-JAE projects supervised
- 3 courses taught on university teaching innovation.
- 1 teaching innovation project.
- Attended several courses on new technologies (3D animation, layout and design, web programming).
- Trainer for Maths-Olympiad students for 8 years.
- Certificado de Aptitud Pedagógica.

AWARDS:

- "Primer premio nacional de fin de carrera" (Spanish Education Ministry).
- "Premio extraordinario de doctorado" and "Premio extraordinario fin de carrera" (University of Granada).
- 6 awards in international Maths Olympiads.
- 4 awards in national Maths Olympiads.

OTHER:

- Accredited as "Profesor Contratado Doctor" by ANECA.
- Member of the coordination team in 2 International Mathematical Olympiads (Madrid 2008 and Amsterdam 2011).
- English level C2 recognised by the Modern Language Center (University of Granada).
- Predoctoral grants "Iniciación a la investigación" and "Beca de colaboración".
- PhD thesis recognised as "international".



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Nombre: LUCIA , ANGELO
Referencia: RYC2019-026475-I
Área Temática: Ciencias matemáticas
Correo Electrónico: angelo@angelolucia.xyz

Título:

Quantum information and quantum statistical mechanics

Resumen de la Memoria:

My research interests lie in the interplay between quantum information and the mathematics of many-body quantum spin systems. I have worked mainly along two research lines: the first one regarding open dissipative dynamics, and a second one regarding tensor network states and the problem of phase classification in 2 dimensional systems.

Dissipative dynamics model the evolution of open systems weakly interacting with an environment, and mathematically in the Markovian approximation they are represented by semigroups of completely positive trace preserving maps (or quantum channels). In my past work I have shown that, under an assumption of fast convergence to a unique fixed point known as rapid mixing, many strong properties of the dynamics can be derived, such as stability against extensive perturbations, as well as bounds on the amount of entanglement and correlations present in the fixed point. I have also developed techniques to show that the rapid mixing condition holds, via a functional inequality known as log-Sobolev inequality, and applied it to a specific class to 1D models. I am currently interested in how dissipation behaves in exotic quantum phases such as topologically ordered models.

A second line of research I have been working on is the classification quantum phases in 2 dimensions. In this case the crucial quantity is the spectral gap of the Hamiltonian, the difference between the two lowest energy levels. I have focused on techniques to show that when spectral gap is non-vanishing for a class of models known as tensor network states. Specifically, we rigorously connected locality property of the boundary of the system to the spectral gap. I am currently interested to apply these results to interesting models such as the quantum spin liquids.

I have also worked on showing that the spectral gap cannot be predicted in general by any algorithm, even for the simpler case of 1D translational invariant models, and I have shown that in 2D there are models whose large system size property cannot be extrapolated by any finite-size scaling analysis.

Resumen del Currículum Vitae:

I obtained my PhD from Universidad Complutense de Madrid, under the supervision of David Pérez García and Toby S. Cubitt, funded by a FPI fellowship from Mineco. I defended my thesis on July 7th 2016, obtaining the highest distinction of sobresaliente cum laude as well as the special PhD thesis award (Premio Extraordinario de Doctorado de la Facultad de Ciencias Matemáticas).

From December 2016 to August 2018, I was a postdoc at QMATH - Center for the Mathematics of Quantum Theory of the Department of Mathematical Sciences and in the Quantum Information Group of the Niels Bohr International Academy at the Niels Bohr Institute, both being part of the University of Copenhagen, Denmark. Since September 2018, I am a Sherman Fairchild Postdoctoral Fellow at the Walter Burke Institute for Theoretical Physics, California Institute of Technology, and I am a member of the Institute for Quantum Information and Matter.

In 2017, I received the "Premio de Investigación Matemática Vicent Caselles" award from Real Sociedad Matemática Española and Fundación BBVA, one out of six yearly awarded prizes for young mathematicians in Spain. In 2018, I received the "Premio de Investigación José Luis Rubio de Francia" from Real Sociedad Matemática Española, one of the most important prizes in Mathematics in Spain. With the prize I received a Start-up Grant from Fundación BBVA, of the value of 35.000 .

I have been the supervisor for the PhD thesis of Ángela Capel Cuevas, together with David Pérez García. Title: "Quantum logarithmic Sobolev inequalities for quantum many-body systems: an approach via quasi-factorization of the relative entropy", defended at Universidad Autónoma de Madrid on December 16th 2019. I have been co-supervisor of John Martyn, University of Maryland, as part of an undergraduate research program at Caltech (SURF), together with Kohtaro Kato and John Preskill.

I am interested in the interplay between quantum information and the mathematics of many-body quantum spin systems. The quality of my research production is well reflected in my publication record, which includes publications in some of the top journals of the fields of



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Mathematical Physics, Physics, and Computer Science. I am currently interested in dissipative dynamics of quantum systems and their relation to phase classification, and in techniques for proving spectral gaps for 2D tensor network models.



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Nombre: MACIAS CASTILLO, DANIEL
Referencia: RYC2019-027693-I
Área Temática: Ciencias matemáticas
Correo Electrónico: daniel.macias@icmat.es

Título:

Arithmetic of L-functions

Resumen de la Memoria:

My research takes place in arithmetic geometry and algebraic number theory. I am particularly interested in the arithmetic properties of the leading terms and special values of L-functions, and their interaction with the Galois module structure of arithmetic groups.

I am therefore interested in equivariant refinements of the Birch and Swinnerton-Dyer conjecture, such as those studied by Mazur and Tate; of the analytic class number formula, such as Stark's conjecture and Rubin's integral refinement; of the Main Conjecture of Iwasawa Theory proved by Wiles, such as those studied by Ritter-Weis or Kakde, or the 'Main Conjecture of non-commutative Iwasawa Theory' for elliptic curves formulated by Coates et al., or the general version due to Fukaya and Kato; and, more generally, in the Tamagawa number conjecture of Bloch and Kato and its equivariant refinement, the 'ETNC', due to Burns and Flach.

One of my main scientific achievements is the development (joint with D. Burns) of the theory of 'organising matrices'. This theory constitutes a vast generalisation and refinement of the construction, in the classical (commutative) Iwasawa theory of elliptic curves, of 'organising modules' by Mazur and Rubin. We have also applied this theory to the study of Leopoldt's conjecture.

Another important achievement (in joint work with Burns and Wuthrich) has been the proof of the relevant case of the equivariant Tamagawa number conjecture, for families of elliptic curves defined over the rationals and satisfying certain hypotheses. This result builds on the theorem of Gross-Zagier and constitutes the only existing evidence for this important conjecture in the most challenging case of positive rank.

In joint work with Bley we also strongly refined and generalised celebrated conjectures of Mazur-Tate and obtained important numerical evidence in support of our predictions.

In very recent work with Burns (<https://arxiv.org/abs/1909.03959>) we have developed a universal theory of 'refined conjectures of Birch and Swinnerton-Dyer type'. This article will constitute a definite treatment of the subject which will provide a suitable framework for future investigation of such conjectures.

One of my objectives for the future is to study the significance of the theory of organising matrices on the non-commutative Iwasawa theory of abelian varieties. I aim to apply this theory to the study of p-adic versions of the BSD conjecture, as formulated by Mazur-Tate-Teitelbaum and generalised by Bertolini-Darmon. I have started preliminary discussions on these topics with S. Vigni (Genova).

In a different direction, another objective for the future is, by building on very recent work with Tsoi (<https://arxiv.org/abs/1910.00569>) to study non-commutative versions of higher rank Euler systems and use them to prove new (non-abelian) cases of the ETNC for Tate motives.

Resumen del Currículum Vitae:

I carried out my undergraduate studies at Imperial College London, and then obtained my PhD from King's College London in the autumn of 2011. I was subsequently a postdoctoral researcher at Ludwig-Maximilians-Universität in Munich during the academic year 2011/12, and then a postdoctoral researcher at ICMAT (of which I am still a member) as a recipient of a Severo Ochoa contract. Since 2016, I am an assistant professor (Profesor Ayudante Doctor) at the Universidad Autónoma de Madrid.

I have published articles in general mathematical journals, including three papers in Crelle and two papers in IMRN, as well as in number theory journals: Acta Arith. (in press), JNT and IJNT. These articles include collaborations with W. Bley (Munich), D. Burns (London) and C. Wuthrich (Nottingham).

I have given talks at international conferences and seminars including, most recently, a plenary session at the 'Jornadas de Teoría de Números' at the UPC in 06/2019, one at a conference on 'Recent advances in the Arithmetic of Galois Representations' in Genova in 07/2019, and a seminar talk at LMU Munich in 11/2019. I am the organiser of the UAM-



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AYUDAS RAMÓN Y CAJAL CONVOCATORIA 2019

Turno de acceso general

ICMAT Number Theory Seminar.

I have been a member of the research team for two successive funded research projects from MINECO, based at ICMAT, the latest of which ends in 2019. In October of 2019 I have applied for a new such project, this time as a co-Principal-Investigator together with F. Presas. Back in 2013 I had also been part of a funded research project from the DFG in Germany, with W. Bley as P. I..

In October of 2019 I also started the supervision of my first PhD student, jointly with J. I. Burgos. In addition, over the last three years I have supervised 4 successful master's theses at UAM, and am currently supervising a fifth such thesis. I have also guided several students in Introduction to Research S.O.-ICMAT grants, and have served as an examiner for numerous master's and undergraduate theses at UAM.



AYUDAS RAMÓN Y CAJAL CONVOCATORIA 2019

Turno de acceso general

Nombre: FITE NAYA, FRANCESC
Referencia: RYC2019-027378-I
Área Temática: Ciencias matemáticas
Correo Electrónico: francesc.fite@gmail.com

Título:

Aritmética de variedades abelianas de baja dimensión

Resumen de la Memoria:

Mis áreas de interés son la teoría de números y la geometría aritmética. Más concretamente, mis intereses se centran en la aritmética de variedades abelianas definidas sobre cuerpos de números. Estoy interesado en estos objetos desde varios puntos de vista: desde la perspectiva de la teoría de representación de grupos, la de los métodos explícitos computacionales y la de los métodos algebraicos y analíticos clásicos.

Dos de mis contribuciones principales se enmarcan en el campo de la Conjetura de Sato--Tate generalizada. Dicha conjetura predice que la distribución de los elementos de Frobenius asociados a variedades abelianas (y, más en general, a variedades algebraicas y motivos) viene dictada por la medida de Haar normalizada de un subgrupo de Lie real compacto del grupo unitario simplectico, llamado el grupo de Sato-Tate asociado a la variedad. La primera contribución (en colaboración con Kiran Kedlaya, Victor Rotger y Andrew Sutherland) es la clasificación (publicada en *Compositio Mathematica*) de los grupos de Sato--Tate de superficies abelianas definidas sobre cuerpos de números. La segunda contribución (en colaboración con Kiran Kedlaya y Andrew Sutherland) es la clasificación completa (prepublicación) de grupos de Sato--Tate de variedades abelianas de dimensión 3 definidas sobre un cuerpo de números.

Más recientemente, me he interesado por las conexiones entre la conjetura de Sato--Tate y la conjetura de Birch y Swinnerton--Dyer. Utilizando métodos de la teoría analítica de números (algunos de ellos basados en profundas conjeturas, tales como vastas generalizaciones de la Hipótesis de Riemann para funciones L de Artin), conjuntamente con Xavier Guitart, hemos conseguido un resultado (publicado en *IMRN*) que establece una conexión entre el tamaño del grupo de Mordell--Weil de una curva elíptica y la velocidad de convergencia hacia la distribución predicha por la conjetura de Sato--Tate.

Finalmente, quisiera destacar que las nuevas técnicas introducidas para el estudio de los grupos de Sato--Tate han demostrado su utilidad para resolver problemas clásicos asociados a variedades abelianas definidas sobre cuerpos de números. Un ejemplo de ello es un resultado obtenido con Xavier Guitart (distribuido entre una prepublicación y una publicación aparecida en *Trans. Amer. Math. Soc.*) que determina el conjunto de álgebras de endomorfismos, salvo isomorfismo, de superficies abelianas definidas sobre el cuerpo de los racionales que son geoméricamente reducibles. Tal resultado de finitud es un caso concreto de una conjetura mucho más general atribuida a Coleman.

Resumen del Currículum Vitae:

Francesc Fité (Barcelona, 1983). Research Scientist en MIT (2019-2020). Doctorado en Matemáticas por la UPC en 2011. Mis áreas de investigación son la teoría de números y la geometría aritmética, especializado en teoremas de equidistribución, grupos de Sato-Tate y modularidad de variedades abelianas.

He recabado experiencia investigadora y docente en centros de primer nivel internacional: postdoctorados en MIT, IAS, Essen, Bielefeld y tres estancias trimestrales en University of Cambridge, MIT y UCSD.

En la actualidad dispongo de 15 artículos de investigación, 2 apéndices y un capítulo de libro. Cuatro de ellos se encuentran publicados en revistas del primer cuartil (uno en *Compositio Mathematica*, dos en *Trans. of the Amer. Math. Soc.*, y uno en *IMRN*) y dos más en revistas de primer nivel (*Research in the Math. Sciences* y *Algebra&Number Theory*). En total acumulan 80 citas hasta la fecha.

He participado como autor de un curso y asistente de proyectos en la "Winter School: Frobenius distributions on curves" (financiación de la Société Mathématique de France) celebrada en CIRM (Luminy) y en la "Arizona Winter School AWS2016" (con financiación de la NSF) celebrada en la Universidad de Arizona. Los proyectos supervisados a los estudiantes en la AWS2016 han dado lugar a dos artículos de los que (sin aparecer como autor) me considero inspirador. Uno está sometido y el otro aparecerá en *Math. Zeit.*

En cuanto a financiación, mi posición en IAS estuvo financiada por la National Science Foundation (vía DMS-1638352 grant). También soy miembro de la ERC Horizon 2020 cuyo PI es Victor Rotger. En 2018 he servido en el comité evaluador del Arithmetic Geometry Panel de la National Science Foundation en Alexandria (Virginia).

He dado charlas de investigación en IAS, Princeton University, MIT, Berkeley, San Diego, ICERM, CIRM, BIRS, Umea, Leuven, Adam



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Mickiewicz University, Duisburg-Essen, Paderborn, Bielefeld, Hannover, Université de Rennes, Vilnius Universitetas, Universidad de Sevilla, Universitat de Lleida, Universitat de València, Universitat de Barcelona, IEC, Centro de Ciencias Pedro Pascual y Universidad del País Vasco.

He sido coorganizador de tres congresos internacionales ("Workshop: effective methods for Darmon points", "Barcelona-Boston-Tokyo Number Theory Seminar in the memory of Fumiyuki Momose", "p-adic methods for Galois representations and modular forms") y de un mes temático en Teoría de Números (Febrero 2017) con financiación del Programa de Excelencia María de Maeztu. He sido coordinador científico en tres ocasiones en Seminario de Teoría de Números de Barcelona (2014, 2017, 2018).

He sido referee de varias revistas internacionales (TAMS, The Ram. Jour., Journal of the LMS, IJNT, Exp. Math., Acta Arithmetica, Contemp. Math., ANTS, e IMRN) y recensor habitual para MR/MathSciNet.

En el aspecto docente destaco el amplio espectro de asignaturas impartidas (de asignaturas de primer año del grado de Ingeniería Informática a asignaturas avanzadas del grado y del máster de Matemáticas: álgebra abstracta, geometría algebraica, teoría de números y análisis complejo). He dirigido dos tesis de final de grado y una tesis de final de máster. Los tres estudiantes siguen carreras académicas (Raúl Alonso, Martí Roset, Pol Torrent).