Book of Abstracts

XX Workshop de Jóvenes Investigadores

The talks will be held in the room Miguel de Guzmán at the Faculty of Mathematical Sciences of the Universidad Complutense de Madrid

September 21-23, 2026

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Abstracts

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Pohozaev Identity for the Spectral Fractional Laplacian

In this talk, we present a Pohozaev identity for the Spectral Fractional Laplacian (SFL). This identity allows us to prove non-existence results for certain semilinear problems. The first work on nonlocal Pohozaev identities goes back to the influential paper by Ros-Oton and Serra (2014), where they consider the Restricted Fractional Laplacian (RFL) on $\mathbb{R}^N$. However, in our setting, the boundary behavior is significantly different, and their integration by parts approach cannot be applied. Instead, we adopt a spectral approach to derive a new identity expressed as a Schur product, through which we recover the classical Pohozaev identity for the Laplacian via a transition matrix.

This is joint work with Matteo Bonforte, María del Mar González, and Clara Torres-Latorre.

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Analysis of Solutions to Non-Autonomous Cauchy Problems with Time-Dependent Domains: An Application to the MGT Model

Numerous models arising across a wide range of scientific fields are described by partial differential equations that relate the temporal evolution of a system to its spatial

behaviour. A particularly useful strategy for studying these equations is to interpret them as abstract Cauchy problems of the form

$$x'(t) = A(t)x(t) + f(t), \qquad x(s) = x_s,$$

in a suitable Banach space. In this formulation, the spatial dependence is encoded in the generally unbounded operator $A(t)$, while the evolution of the system is analysed as an ordinary differential equation. This change of perspective provides a unified framework for studying the existence, uniqueness, and regularity of solutions, even when the operator depends explicitly on time.

In the non-autonomous setting, the semigroup associated with a single operator must be replaced by a two-parameter evolution system $U(t, s)$. We will first consider the case in which the operators share a constant domain and examine the relationship among classical, mild, and weak solutions. We will then address the more delicate case in which the domains $D(A(t))$ vary with time. Following Kato's hyperbolic framework, we will introduce a common regularity space Y and a common test space Z, which make it possible to define Y-valued and Z-weak solutions and to compare them with classical and mild solutions.

As an application, we will study a fourth-order Moore–Gibson–Thompson-type equation with time-dependent coefficients. MGT models arise in the study of high-intensity acoustic wave propagation and can incorporate thermal relaxation and memory effects. Time-dependent parameters are natural when properties of the medium, such as the speed of sound, relaxation time, or diffusivity, evolve during the process.

After reformulating the equation as an abstract first-order system in a Hilbert space, we will show that the variable coefficients can give rise to genuinely time-dependent domains. Consequently, constant-domain theory is not sufficient to study the problem. However, the family of adjoint operators has a common domain, allowing the tools from both settings to be combined.

Under suitable assumptions, existence and uniqueness of solutions are obtained. For regular data, mild, Y-valued, classical solutions continuous in Y, and Z-weak solutions are equivalent; for finite-energy data, mild and Z-weak solutions are equivalent. The application therefore shows how the abstract formulation provides a rigorous treatment of a physical model whose time dependence lies beyond classical constant-domain theory.

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Robustness of spectral gap undecidability

Quantum spin systems are mathematical models used to represent physical systems in the context of quantum information theory and condensed matter physics. In those systems, a key property is the spectral gap, which is the difference between its two lowest possible energy values. In particular, it is of special interest if this difference closes to zero as the system size grows. However, this problem was previously shown to be undecidable for one or more dimensions: no general algorithm exists for its resolution.

We will focus on bringing the general constructions in these previous results closer to physically realizable systems, by studying two common properties in them: symmetries and perturbations. Could they reduce the complexity of the problem? We find that the spectral gap problem remains undecidable in 2D even with stronger symmetry constraints. In 1D, we observe that the family with undecidable behaviour is extremely sensitive to perturbations: arbitrarily small perturbations can render the problem decidable.

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Lineability in Linear Dynamics

Linear dynamics investigates the behavior of continuous linear operators through notions such as hypercyclicity and cyclicity. In this talk, we explore recent results on the algebraic and geometric structure of classes of operators arising in this setting, with particular emphasis on lineability.

We consider the space $\mathcal{L}(X)$ of continuous linear operators on an infinite-dimensional Fréchet space X, endowed with the strong operator topology (SOT). We demonstrate the existence of both SOT-dense and SOT-closed infinite-dimensional subspaces contained in the class of non-cyclic operators, as well as analogous results for other classes, including non-injective and non-surjective operators. Furthermore, we examine lineability phenomena in classical sequence spaces, showing that the set of non-cyclic operators on ℓ_p $(0 < p < \infty)$ contains an isometric copy of ℓ_p.

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POD-ROM approximations for out of sample parameters

The aim of this talk is the numerical approximation of parametric time-dependent reaction-diffusion PDEs by proper orthogonal decomposition reduced order methods (POD-ROMs). ROMs can significantly lower the computational cost required to obtain numerical approximations while also trying to provide sufficiently accurate ones. An interesting case is that of equations that depend on one or several parameters. The final goal of the talk is to propose a new method to provide accurate approximations for parameter values that are not part of the snapshots dataset used for constructing the corresponding POD basis.

The proposed POD method is based on finite differences with respect to time and parameters. We will prove pointwise in time estimates that are valid for any value of the parameters (including out of sample values). Some numerical experiments will show the good performance of the method.

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How Pluralistic Ignorance and Social Norms Shape Public Support for Road Pricing

Public opposition remains a key barrier to the implementation of economically efficient environmental policies. Distance-based road pricing—where drivers pay per kilometre with fees varying by time and location—is theoretically optimal [1] yet politically contentious.

We investigate the drivers of public support for distance-based road pricing using original data from two stated choice experiments conducted in the Community of Madrid in 2022 and 2023 ($N = 638$ residents). Respondents chose between two road pricing alternatives and a status quo representing current tolls, fuel taxes, and the Madrid Central low-emission zone. Policy alternatives varied along five dimensions: urban peak price, urban off-peak price, non-urban price, electric vehicle discount, and revenue allocation. Before completing the choice tasks, respondents were randomly assigned to one of five information treatments (congestion and pollution, public revenues, redistribution, road pricing framing, social norms) or a control group. The post-choice module elicited three social norm constructs following Bicchieri [4]: **empirical expectations** (EE, beliefs about actual car use), **personal normative beliefs** (PNB, own ideal car use level), and **normative expectations** (NE, beliefs about others' ideal car use). Those norms were used to elicit *pluralistic ignorance*: the systematic tendency of individuals to misperceive how widely pro-environmental preferences are shared in their social environment [2], [3].

Main results. We document four findings.

(i) Policy design dominates. Overall support is substantial—77% of choices favour a pricing alternative—but highly sensitive to design. Support declines with price stringency and increases markedly when revenues are earmarked for public transport and active travel (coefficient ≈ 0.79, $p < 0.01$), equivalent in utility to a 0.63EUR reduction in the urban peak price. Informational treatments produce no significant shift in support, suggesting that one-shot fact provision is insufficient to move entrenched preferences.

(ii) Substantial preference heterogeneity. Latent class analysis identifies four classes: *pro-policy* (16.8%), *anti-policy* (14.5%), *moderate pro-policy* (47.0%), and *mixed* (21.7%). These groups differ markedly in price sensitivity, valuation of revenue use, and demographic composition. Car users and right-leaning voters are more likely to belong to the anti-policy class, while higher institutional trust predicts membership in the pro-policy classes.

(iii) Pluralistic ignorance exists and predicts support. Respondents overestimate others' tolerance for car-heavy behaviour by 8 percentage points on average ($\bar{\text{NE}} = 34.0\%$ vs. $\bar{\text{PNB}} = 26.0\%$; $t(456) = 8.49$, $p < 0.001$). This misperception is positively associated with policy support: respondents who overestimate how pro-car others are show greater demand for formal regulation, consistent with a *substitution* between informal norm-based and formal policy-based governance. Personal normative beliefs are negatively associated with support ($\beta = -1.056$, $p < 0.05$), while the effect of pluralistic ignorance is attenuated among high-trust respondents.

(iv) Social norm influences on behaviour are largely null. A separate elicitation of individual-level sensitivity to empirical and normative expectations—via hypothetical car-use scenarios—reveals that the large majority of respondents (71%) are indifferent to peers' behaviour and beliefs, with no statistically significant effect on policy support.

Implications. Overall support is substantial, but highly sensitive to design. Successful policies should have low to moderate pricing and earmark revenues to public transport and active travel. The positive association between pluralistic ignorance and road pricing support points to an important asymmetry—correcting norm misperceptions may strengthen voluntary compliance but simultaneously reduce support for coercive instruments. Policymakers face a strategic choice in norm communication that has not been previously recognised in the transport acceptability literature.

Joint work with Alberto Antonioni[1], Alice Ciccone[2], Cloé Garnache[3], Askill H. Halse[2] and Francesca Lipari[4].

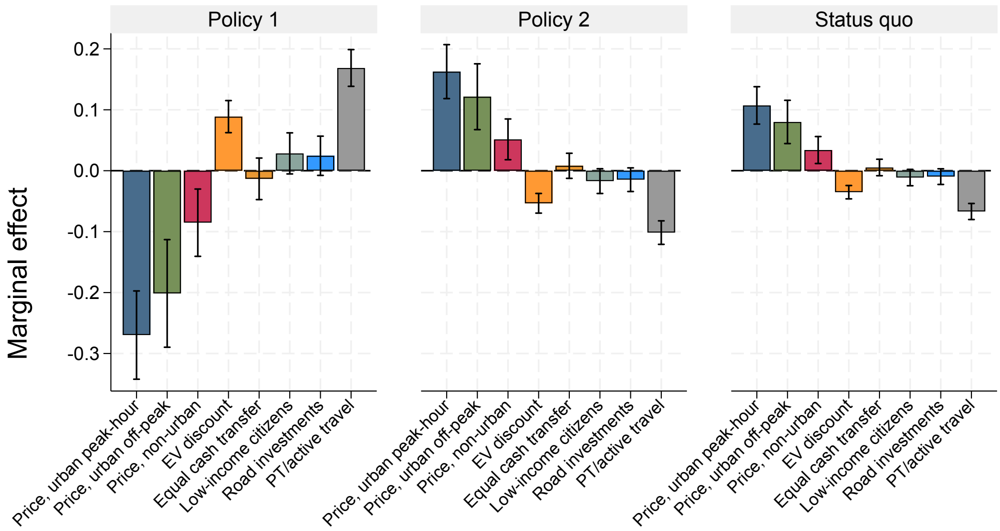

Figure 3.1: Marginal effects of a change in Policy 1.

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Theory for groupoid equivariant neural networks

Equivariance is a powerful inductive bias in machine learning, allowing neural networks to incorporate known symmetries of the data directly into their architecture. In this talk, we present a groupoid-based framework for constructing equivariant neural networks, in which symmetries can act locally and may have domains of definition with boundaries. We develop the mathematical framework underlying these networks using groupoid representations and introduce the notion of local rigid bisections, which provide coherent transformations between regions of the domain. We then illustrate the framework through an example involving the action groupoid of the Euclidean group on the plane, restricted to a domain with boundary. By explicitly taking the boundary structure into account, the resulting tangent-cone groupoid may have several connected components, leading to additional constraints on the structure of the equivariant channels.

◇

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Algebraic stacks and good moduli spaces

In this talk, we make a quick overview of the properties of algebraic stacks and how their study allows one to prove necessary and sufficient conditions for the existence of a *good moduli space* for moduli problems represented by an algebraic stack of finite type over a field of characteristic 0. These results are based on the recently published papers by Jarod Alper, Jack Hall, Daniel Halpern-Leistner, Jochen Heinloth and David Rydh, among others.

It is also described how these results were applied to the case of coherent sheaves with zero-dimensional support in a separated scheme of finite type over a field of characteristic 0 to identify the moduli space in this case as the symmetric product of said scheme. This was known in the case of quasi-projective schemes, and this construction allows for a broad generalization of said case.

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Physics-Guided Reduced-Order Learning for Fast and Reliable Fluid Flow Prediction for Industrial Applications

The increasing use of artificial intelligence in fluid mechanics offers new opportunities for accelerating simulations, extracting information from complex datasets, and developing real-time predictive tools. However, conventional deep-learning approaches often require large training datasets and may struggle to retain physically meaningful information when applied outside the conditions represented during training. This work explores an alternative strategy in which dimensionality reduction and machine learning are combined to construct efficient, physics-informed surrogate models for complex fluid flows.

The proposed framework first employs data-driven modal decomposition techniques to identify the most energetic and dynamically relevant structures contained in high-dimensional flow databases. The original system can therefore be represented through a limited set of modal coefficients describing its dominant spatial and temporal behaviour. Neural-network architectures are subsequently trained in this reduced representation rather than directly on the complete flow field.

Operating in this compact space substantially decreases the complexity of the learning problem while retaining information associated with the underlying flow dynamics. The resulting models can be used for several complementary tasks, including rapid approximation of computational fluid dynamics solutions, recovery of spatial flow fields from limited measurements, prediction of temporal evolution, and exploration of systems depending on multiple physical or geometrical parameters. Recent applications also demonstrate the capability of these methodologies to enrich and generate parametric databases, facilitating their use in optimization and forecasting problems.

Particular attention is given to the robustness and generalization properties obtained when machine-learning models are constrained through physically meaningful reduced representations. Results from different fluid-flow configurations indicate that hybrid reduced-order learning approaches can provide greater reliability outside the original training conditions than fully data-driven alternatives.

These developments illustrate how modal decomposition and machine learning can form the basis of computationally affordable and interpretable artificial-intelligence models for fluid mechanics. Although the examples presented focus mainly on flow-related problems, the methodology is readily transferable to other data-intensive applications governed by complex physical dynamics.

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The Bernstein-Sato polynomial and the annihilator of a rational function

The study of the Bernstein-Sato polynomial occurs in the intersection of many areas of mathematics such as algebraic geometry, singularity theory, topology of varieties, representation theory and differential equations, among others. It turns out that the roots of this polynomial encode important invariants of the singularities of the considered function.

In the talk we will discuss the recently introduced Bernstein-Sato polynomial of a rational function. An equivalent problem is to compute the annihilator of the rational function, which can be done by using the annihilators of the numerator and the denominator. Some non-vanishing condition on the Bernstein-Sato ideal of the pair given by the numerator and the denominator, pops up in a natural way. The method has been implemented in SINGULAR and relies on Gröbner bases in noncommutative PBW algebras. Our algorithm allows us to exhibit, for the first time, some explicit non-trivial examples of Bernstein-Sato polynomials of rational functions. This is joint work with Manuel González-Villa, Viktor Levandovskyy and Jorge Martín-Morales.

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Derived Categories and Functors in Algebraic Geometry

This thesis develops the foundations of derived categories and derived functors in algebraic geometry, with applications to coherent sheaves on smooth projective curves over an algebraically closed field. Starting with abelian categories, it constructs the derived category by inverting quasi-isomorphisms in the homotopy category and examines the role of resolutions in defining derived functors. This formalism is applied to the bounded derived category of coherent sheaves to study derived global sections, direct and inverse images, Hom and tensor products, together with their adjunctions and compatibility formulas.

As a geometric application, Grothendieck–Verdier duality is presented and Serre duality is deduced using the structure morphism of the curve. The category of coherent sheaves is also shown to have homological dimension one, yielding a noncanonical decomposition of bounded complexes into direct sums of their shifted cohomology sheaves. Finally, Serre duality, the additivity of the Euler characteristic and the exact sequences associated with divisors are combined to obtain the Riemann–Roch theorem for line bundles.

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Advances on decisional attacks against PLWE based on polynomial roots

Lattice-based cryptography has achieved an extraordinary success in the last years, especially since NIST launched a public contest in 2017 to standardize different sets of quantum-resistant primitives. With five candidates selected for standardization, three of them belong to the lattice-based category (i.e. ML-KEM, ML-DSA and FN-DSA).

In the present talk, we are concerned in particular with the Polynomial Learning With Errors problem, which was introduced in [4]. Let us denote by R the quotient ring $R := \mathbb{Z}[x]/(f(x))$ with $f(x) \in \mathbb{Z}[x]$ of degree N, monic and irreducible over $\mathbb{Z}[x]$, and let $q \geq 2$ be a prime. Set $R_q := \mathbb{F}_q[x]/(f(x))$ and consider an R_q-valued uniform random distribution U and an R_q-valued discrete Gaussian distribution χ_{R_q}. The PLWE problem in decision form, the version we investigate in this work, consists in guessing, with non-negligible advantage, if a set of pairs $\{(a_i(x), b_i(x))\}_{i\geq 1} \subseteq R_q \times R_q$ of arbitrary size has been sampled either from $U \times U$ or from the PLWE distribution, where each sample is defined as $(a_i(x), b_i(x) = a_i(x)s(x) + e_i(x))$, with $e_i(x)$ sampled from χ_{R_q} and $s(x) \in R_q$ a secret value.

The main contribution of [2] is to completely generalize the extension idea presented in [1] against the attacks developed by [3].

The key tool of these extensions is to combine the evaluation-at-α map with the trace map [1]. This composition of maps allows one to project R_q to a subring $R_{q,0}$ of large enough dimension over which the PLWE problem turns solvable in expected polynomial time with overwhelming probability of success. Then, the composition is suitably applied to each *distinguishability condition* in [3], depending upon the attack to be extended.

This talk will explain the advances presented in [2], as well as its limits and future directions to be explored.

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Pointwise convergence of Schrödinger solutions along highly tangential curves

Since the foundational work of Carleson in 1980, the problem of pointwise convergence of solutions to the Schrödinger equation to the initial datum has been a central topic in harmonic analysis. A natural generalization is to study this convergence as the initial point is approached not vertically in time, but along a prescribed curve $\gamma(t)$ with $t \to 0$. That is, we seek conditions on f such that

$$\lim_{t\to 0} e^{it\Delta} f(x + \gamma(t)) = f(x) \quad \text{a.e. } x \in \mathbb{R}^n.$$

Previous works by Cho, Lee and Vargas [2], and later by Cao and Miao [1] established sharp results for Hölder curves with index $\alpha \geq 1/2$. In this talk, we will discuss the more delicate regime $\alpha < 1/2$, where the curves become highly tangential. For the model family $\gamma(t) = (t^{\alpha_1}, \ldots, t^{\alpha_n})$ with $\alpha = \min_j \alpha_j < 1/2$, we will show that the critical Sobolev regularity for almost everywhere convergence is

$$s = \max\left\{\frac{1-2\alpha}{2}, \frac{n}{2(n+1)}\right\}.$$

The proof relies on a decomposition of the maximal function, a refined L^2 estimate for the Schrödinger operator by Du and Zhang [3], and a density argument to control the contribution of the supremum along the curve for large times.

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Finite sets and submonoids are mapping degree sets

Let M, N be two oriented closed connected manifolds of dimension n. We define the mapping degree set as $\deg(M, N) = \{\deg(f) | f : M \to N\}$. A cornerstone question is which sets of integers can appear as $\deg(M, N)$ for some M, N. By cardinality reasons, not all sets can be mapping degree sets.

In joint work with C.Costoya and A.Viruel, we prove that any finite set of integers A, containing 0, is a mapping degree set. We do this by a series of explicit constructions that allow to produce new mapping degree sets.

In further work with C.Costoya, B.Valverde and A.Viruel, we enhance the method to prove that mapping degree sets are stable under multiplication by finite subsets of integers containing 0, and by sets obtained from additive submonoids of $\mathbb{Z}$, through finitely many sums and products. As a consequence, we obtain a broad family of infinite mapping degree sets, including finite unions of arithmetic progressions starting at 0.

These results solve questions posed by Neofytidis, Wang, and Wang.

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Khovanov homology of knots and links

This talk explores Khovanov homology as a Topological Quantum Field Theory (TQFT) that categorifies the unnormalized Jones polynomial. After reviewing the classical polynomial and the cube of resolutions, we introduce the categorical machinery of 2-cobordisms to rigorously formulate the Khovanov functor. Finally, we contrast this algebraic framework with Viro's combinatorial approach using enhanced states, illustrating the direct correspondence between both constructions.

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Rapid mixing for Gibbs measures in Riemannian manifolds

Given some sufficiently smooth, generally non-convex, function F on a Riemannian manifold, and a fixed inverse temperature, the problem of sampling with respect to the associated Gibbs distribution has played a central role in several areas, such as statistical mechanics or non-convex optimization. A natural approach to do so is to simulate the Langevin diffusion associated with F, whose stationary distribution is precisely the Gibbs distribution. However, obtaining quantitative convergence guarantees in this non-convex, geometric setting remains difficult.

In this work, we identify a set of assumptions on F and the underlying manifold under which a log-Sobolev inequality (LSI) holds for the Gibbs distribution in the low-temperature regime. As a consequence, we obtain exponential convergence of the Langevin diffusion to its stationary distribution.

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Free Banach Lattices

Free objects, such as the free group over a set, have been widely studied in algebra for decades. Recently, it has been observed that free structures can also be applied to tackle open problems in functional analysis. In this talk, we present the definition and basic properties of the free Banach lattice over a Banach space, alongside recent results and open problems in the area.

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Classification of semilinear elliptic equations in unbounded domains

We discuss non-existence and classification results for the model semilinear equation (Lane-Emden equation) in unbounded domains such as the whole space, the half-space, and cones. A special emphasis will be placed on explaining the key techniques used in classical results - *e.g.* the method of moving planes, doubling lemmas, P-functions, monotonicity formulas – and their limitations. We will also discuss the role of "stability". We conclude by discussing recent results on Riemannian manifolds, and some open problems. Based on joint works with L. Dupaigne, A. Farina, G. Ciraolo.

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Telling knots apart: from the Alexander polynomial to link Floer homology

Telling one knot apart from another is an extremely difficult (unsolved) problem. For this reason we attach several algebraic invariants to a knot, or more generally, to a link. In this talk, I will (very briefly) speak about the Alexander polynomial and the path towards something that can be seen as a vast generalization of it: link Floer homology.

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λ-Forman–Ricci Curvature on Graphs

Several discrete versions of Ricci curvature have been proposed, as the geometrical properties of a network can be used to understand important information associated with it. In this work, we study the properties of the λ-Forman–Ricci curvature, a concept that generalizes and integrates the Forman–Ricci curvature and the augmented Forman–Ricci curvature. We show that this definition captures the essence of Ricci curvature on Riemannian manifolds by proving discrete analogues of important results in geometry. We also obtain optimal bounds for this curvature in terms of some fundamental graph parameters, such as the size and the isoperimetric constant.

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Gaussian processes via Hilbert space approximation and multi-group Bayesian Gaussian process models

Gaussian processes (GPs) provide a flexible non-parametric framework for modeling complex functional relationships, but their practical application can be limited by computational cost and by the need to accommodate structured dependence across groups. In this presentation, we discuss two complementary developments aimed at extending the applicability of Bayesian Gaussian process models within probabilistic programming frameworks.

First, we consider a low-rank Hilbert space approximation for stationary Gaussian processes based on Laplace eigenfunctions. This approach replaces the standard GP representation with a basis-function expansion that substantially reduces computational complexity while retaining the flexibility of the original model. We examine the practical performance of the approximation and provide recommendations and diagnostics for selecting the number of basis functions and the domain boundary, two key quantities controlling approximation accuracy and computational efficiency.

Second, we address Gaussian process modeling when functional responses are observed across multiple, potentially correlated groups. We consider covariance structures that jointly model continuous inputs and group membership while allowing the dependence between groups to be learned from the data. In particular, we develop Bayesian formulations in which distances between groups are treated as unknown parameters while satisfying the axioms of a distance metric, either through direct constrained parameterizations or through embeddings in Euclidean space. We also investigate extensions of separable continuous and categorical kernels that allow group-level covariance structures to be inferred.

The proposed approaches are evaluated using simulated data. All models are implemented in Stan and estimated using Hamiltonian Monte Carlo, illustrating how scalable GP approximations and flexible multi-group covariance structures can be incorporated into a unified Bayesian probabilistic programming workflow.

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Superselection sectors of lattice gauge theories: from $\mathbb{Z}^2$ to lattices with boundary

Physically inequivalent representations of the algebra of observables of a quantum system are organized into superselection sectors. In this talk we introduce this notion and illustrate it through the quantum double model, a prototypical example of a quantum spin system that can be regarded as a lattice gauge theory. Following an approach analogous to that of Doplicher, Haag and Roberts in algebraic quantum field theory, we describe the superselection sectors of this model when it is defined on the square lattice. We then examine how this sector structure is modified when the underlying lattice is no longer $\mathbb{Z}^2$ but is restricted to the upper half-plane, showing that new phenomena, such as the condensation of certain sectors, appear in this setting.

This is joint work with Joan Claramunt (UPC) and Fernando Lledó (UC3M – ICMAT).

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Mathematics applied to cardiovascular health

Mathematics has an extraordinarily wide range of applications and is, in a very real sense, the engine driving every other science; whenever a discipline needs to describe, predict or decide, it ends up borrowing a mathematical language. This talk is an illustration of that idea in one particular setting, cardiovascular health, and it is also a personal account. I will begin by introducing myself and briefly describing my own path; a degree in Data Science in Navarre, with a strong mathematical component, followed by a Master's in Advanced Mathematics at the Universidad Politécnica de Madrid, and a Master's Thesis carried out with the ModelFLOWs research group at the ETSIAE.

The rest of the talk is devoted to that thesis. Cardiovascular diseases are the leading cause of death worldwide, which makes early and accurate diagnostic tools essential. The work focuses on the clinical integration of an artificial intelligence tool for echocardiography analysis, built on a preprocessing pipeline of modal decompositions, (the Singular Value Decomposition (SVD) and High Order Dynamic Mode Decomposition

(HODMD)), feeding a MAE-ViT model previously developed by the group. Starting from a thorough understanding of how this tool works, I designed and implemented CardioView, a clinical interface that allows healthcare professionals to load DICOM echocardiograms, run the preprocessing and inference pipeline, and visualise diagnosis and prognosis results in an interpretable way. An incremental retraining system was also developed, so that the model can be continuously updated with new cases collected from different hospitals during the use of the platform, in the spirit of the fine-tuning strategies employed by large language models. In parallel, the HODMD algorithm was applied to phonocardiograms, with the aim of discriminating recordings from healthy and pathological subjects through their dynamic modes.

My emphasis throughout will be on the mathematics underneath, how a complicated, noisy, high-dimensional signal can be rewritten as useful information. Rather than presenting a finished product, I would like to go through the difficulties that came up along the way and the ideas that allowed us to get around them. Simply to show new researchers the potential of mathematics.

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Segregation phenomena and free boundaries

Segregation phenomena occur when strong interactions prevent different populations or phases from coexisting in the same region. As the strength of the interaction increases, the different components tend to separate and occupy disjoint regions. The interface between these regions is not known in advance and must be determined as part of the solution. Hence, the limiting configuration is naturally described by a free boundary problem. These problems arise in several areas, such as population dynamics, materials science, and quantum systems. A central question is to understand how the equations governing the individual phases determine the geometry and regularity of the interface separating them.

In this talk, we will review the classical theory of segregation problems and discuss a parabolic model in which the diffusion is governed by fully nonlinear operators. We will describe the main ideas behind the existence of Lipschitz solutions, the analysis of blow-up limits, and the regularity of the free boundary at nondegenerate points.

This is joint work with Emily Casey (U. Minnesota), Cornelia Mihaila (Saint Michael's College), and Clara Torres-Latorre (ICMAT).

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Quantization as a functor: from time evolution to TQFTs

Geometric quantization is a well-known algorithm that assigns Hilbert spaces to symplectic manifolds in a systematic, rigorous way. In this talk we will discuss how it can be applied to families of symplectic manifolds that change over time. By regarding these spaces as objects in a category, we will show that geometric quantization can be understood as a functor, and we will examine how endowing this category with different additional structures yields different quantum theories. Among these, we will focus on topological quantum field theories, or TQFTs, and their application to knot theory.