ESCUELA DE DOCTORADO DE LA UNIVERSIDAD DE CÁDIZ

# VIII Jornadas Doctorales del Programa de Doctorado en Matemáticas

9, 16 y 17 de noviembre de 2022

**Comité científico**

Dra. Elena Fernández Aréizaga
Dr. José Rafael Rodríguez Galván
Dr. Francisco Ortegón Gallego

**Comité organizador**

Dra. Concepción Muriel Patino
Dr. Antonio Jesús Calderón Martín
Dr. Francisco Ortegón Gallego

## Programa del miércoles 9 de noviembre de 2022. Salón de Grados 1, Facultad de Ciencias

| Hora | Conferenciante/Ponente | Título |
|---|---|---|
| $10^h15$'- $10^h30$' | **Francisco Ortegón Gallego**<br>Coordinador del Programa de Doctorado en Matemáticas de la UCA | Apertura de las *VIII Jornadas Doctorales del Programa de Doctorado en Matemáticas.* |
| $10^h30$'- $11^h30$' | **Ivana Ljubic**<br>Professor of Operations Research at the ESSEC Business School of Paris. | Bilevel Optimization Models for the Min-Max Connected Component Problem and its Variants. |
| $11^h30$'- $11^h50$' | **Antonio Jesús Pan Collantes**<br>Universidad de Cádiz. | Nuevos métodos de integrabilidad de distribuciones de campos vectoriales. |
| $11^h50$'- $12^h10$' | **Ana del Rosario Niño López**<br>Universidad de Cádiz. | Automatización y modelización del clon leucémico en Leucemia Linfoblástica Aguda y su tratamiento. |
| $12^h10$'- $13^h10$' | **Pepa Ramírez Cobo**<br>Profesora Titular de la Universidad de Cádiz. Departamento Estadística e Investigación Operativa. | Some results and open problems concerning Markovian Arrival processes. |

- **Todas las sesiones presenciales tendrán lugar en el Salón de Grados 1 de la Facultad de Ciencias, salvo la del jueves 17, que se celebrará en Salón de Grados 2 de la Facultad de Ciencias.**
- **La única sesión que se desarrollará por videoconferencia es la de la tarde del miércoles 16 en el enlace indicado.**
- **Se ha creado el curso *VIII JORNADAS DOCTORALES DEL PROGRAMA DE DOCTORADO EN MATEMÁTICAS* en el campus virtual que actualizará la información sobre las Jornadas y donde estarán disponibles las presentaciones de los conferenciantes invitados.**

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## Programa de la mañana del miércoles 16 de noviembre de 2022. Salón de Grados 1, Facultad de Ciencias

| Hora | Conferenciante/Ponente | Título |
|---|---|---|
| $11^h30'$- $12^h30'$ | **Juan Casado Díaz**<br>Catedrático de la Universidad de Sevilla. Departamento de Ecuaciones Diferenciales y Análisis Numérico. | An introduction to the homogenization of PDEs with applications to the behaviour of composite materials. |
| $12^h30'$- $13^h30'$ | **Faustino Maestre Caballero**<br>Profesor Titular de la Universidad de Sevilla. Departamento de Ecuaciones Diferenciales y Análisis Numérico. | On optimization problems: optimal design of materials. |

## Programa de la tarde del miércoles 16 de noviembre de 2022 – https://meet.google.com/kkz-oecz-gdo.

| Hora | Conferenciante/Ponente | Título |
|---|---|---|
| $17^h00'$- $18^h00'$ | **Jin Wang**<br>Professor and UNUM Chair of Excellence, Department of Mathematics, University of Tennessee at Chattanooga, EE.UU. | Numerical Methods for Fluid-Structure Interaction. |
| $18^h00'$- $19^h00'$ | **Eleni Panagiotou**<br>Assistant Professor. School of Mathematical and Statistical Sciences, Arizona State University, EE.UU. | Entanglement of open curves in 3-space. |

## Programa del jueves 17 de noviembre de 2022. Salón de Grados 2, Facultad de Ciencias

| Hora | Conferenciante/Ponente | Título |
|---|---|---|
| $12^h30'$- $13^h30'$ | **Francisco Marcellán Español**<br>Catedrático de Universidad/Profesor emérito en la Universidad Carlos III de Madrid. | Sobolev orthogonal polynomials. Theory and applications. |

# VIII Jornadas Doctorales del Programa de Doctorado en Matemáticas

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## CONFERENCIANTES INVITADOS Y PONENTES

**Ivana Ljubic**. ESSEC Business School of Paris.

**Bilevel Optimization Models for the Min-Max Connected Component Problem and its Variants**. **Miércoles 9, 10h30'**.

Given an undirected graph G and an integer budget B, we study the Minimum Maximal Connected Component Problem (MinMaxC) that asks to find a subset S of at most B vertices to remove from G in such a way that the size of the largest connected component in the remaining graph is minimized. The MinMaxC and its capacitated version, known as the Capacitated Vertex Separator Problem, are of great importance in the analysis and protection of communication/social networks against possible viral attacks, and for matrix decomposition algorithms. We provide new bilevel interpretations of these problems and model them as two-player Stackelberg games, where the leader interdicts the vertices (i.e., decides on the subset of vertices to remove), and the follower solves a combinatorial optimization problem on the resulting graph. Using this approach, we develop a computational framework based on an integer programming formulation in the natural space of the variables. We derive three different families of strengthening inequalities and show that they can be separated in polynomial time. Our extensive computational study conducted on available benchmark instances from the literature reveals that our new exact method is competitive against the state-of-the-art algorithms, and is able to improve the best known results for several difficult classes of instances.

This talk is based on the paper: Fabio Furini, Ivana Ljubic, Enrico Malaguti, Paolo Paronuzzi: Casting Light on the Hidden Bilevel Combinatorial Structure of the Capacitated Vertex Separator Problem. Oper. Res. 70(4): 2399-2420 (2022).

**Pepa Ramírez Cobo**. Universidad de Cádiz.

**Some results and open problems concerning Markovian Arrival processes**. **Miércoles 9, 12h10'**.

Markovian arrival processes (MAPs) constitute a wide class of stochastic processes that allow for the modeling of non-exponential and dependent inter-arrival times. These properties make the MAPs suitable for modeling an assortment of real world situations in Reliability, Insurance, Climatology or Medicine. In this talk, we will first review known properties of MAPs and different approaches undertaking statistical inference. Then, we will present some novel findings concerning the MAP counting process, and detail a set of challenging open problems to look into. To conclude, a numerical application regarding the modeling of recurrence times in patients suffering from bladder cancer shall be illustrated.

**Juan Casado Díaz**. Universidad de Sevilla.

**An introduction to the homogenization of PDEs with applications to the behaviour of composite materials**. **Miércoles 16, 11h30'**.

The goal of the talk is to carry out an introduction to homogenization theory for PDE. From a mathematical point of view, the problem is to pass to the limit in a sequence of PDE with high oscillating coefficients. The sets where the equations are posed can vary too. To simplify we limit ourselves to the case of a sequence of linear elliptic equations posed in a fixed domain. We will recall some classical results. From the applications point of view, this theory allows us to deal with heterogeneous materials with a complex structure. It describes the behaviour of materials obtained as a mixture of some elementary components.

**Faustino Maestre Caballero**. Universidad de Sevilla.

**On optimization problems: optimal design of materials**. **Miércoles 16, 12h30'**.

Throughout history there have been many optimization problems of various forms and natures raised by man. From finding the shortest distance between two points, to the best aerodynamic design of an aerospace ship, through the optimal distribution of a therapy. That is, setting an objective to achieve is about finding the element that optimizes said objective. We can fit this type of problems within the field of optimal design problems, in particular we will present results in the case of optimal desing problems of materials. We will analyz e issues related to the existence of an optimal solution, necessary conditions of optimality as well as numerical algorithms for solving the problem.

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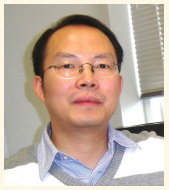
## CONFERENCIANTES INVITADOS

**Jin Wang**. University of Tennessee at Chattanooga.



**Numerical Methods for Fluid-Structure Interaction**. **Miércoles 16, 17h00'**.

The interaction between fluid flows and immersed solid structures leads to nonlinear multi-physics phenomena that have applications to a wide range of scientific and engineering disciplines. There are many numerical techniques currently available for computing fluid-structure interaction, and we will focus on methods of the immersed boundary type in this presentation. Starting from the original immersed boundary method, we will discuss a few improvements of the method as well as some applications. Following that we will describe an extension of this computational approach to deal with immersed structures that occupy a nonzero volume. Such an extension would allow us to handle more realistic and more sophisticated structures described by detailed constitutive laws. We will illustrate the application of these methods through several numerical examples.

**Eleni Panagiotou**. Arizona State University.

**Entanglement of open curves in 3-space**. **Miércoles 16, 18h00'**.

We have all experienced entanglement in our every day life; from tying our shoelaces to entanglement of headphones and to the textiles that we wear, we intuitively understand the mechanical effects of entanglement. In biology, entanglement is present in DNA and in proteins, where it can either facilitate or disrupt function and lead to disease. Polymer entanglement is also important in industry since it regulates viscoelastic properties of material. But, what is entanglement? How can we measure it? This question has challenged scientists for many decades. Thinking of these filaments as mathematical curves in space, we could try to employ tools from topology to study their complexity. In the context of mathematical topology, we can rigorously classify knots and links (simple closed curves in space). This approach has been very successful to understand aspects of DNA topology. But the majority of physical filaments cannot be modeled by knots/links since they have distinct ends. In this talk we will see how we can use tools from topology and geometry to create a new framework in mathematics that extends the study of knots and links to all simple open curves in 3-space. We will also show hand-in-hand how these new mathematical advances are immediately applied to reveal new aspects of materials and biopolymer function through computation and testing against experimental data. This cutting edge area of research is promising for both a novel approach to knot theory, as well as an unexpected application of mathematics to contributing to answering major pressing problems related to health and disease, as well as manufacturing.

**Francisco Marcellán Español**. Universidad Carlos III de Madrid.

**Sobolev orthogonal polynomials. Theory and applications**. **Jueves 17, 12h30'**.

The study of polynomials orthogonal with respect to a Sobolev inner product has attracted the attention of many researchers during the last years (see [3] for a survey on this topic). Their constructive approach in the univariate case as well as their properties in comparison with standard orthogonal polynomials in approximation theory (Fourier series) and numerical analysis (spectral methods for Boundary Value problems for ODEs and PDEs) have been recently pointed out.
In this talk we will focus the attention on the Sobolev orthogonal polynomials associated with the so-called coherent pairs of measures ([2]) and the coherent pairs of the second kind (see [1]), respectively. The characterization of such pairs of measures will be discussed. In the second case, when one of the measures is classical (Jacobi and Laguerre) we will analyze the corresponding sequences of Sobolev orthogonal polynomials. We will deduce analytic properties of them. Applications to Boundary Value problems for elliptic ODEs will be analyzed in the framework of spectral methods in such a way we improve some results presented in [4].

## References


[1] H. Hancco Suni, G. A. Marcato, F. Marcellán and A. Sri Ranga, *Coherent pairs of measures of second kind and associated Sobolev orthogonal polynomials. A functional approach* . 2022. Submitted.

[2] A. Iserles, P. E. Koch, S. P. Nørsett and J. M. Sanz-Serna, *On polynomials orthogonal with respect to certain Sobolev inner products*. J. Approx. Theory **65** (1991), no. 2, 151–175.

[3] F. Marcellán and Yuan Xu, *On Sobolev Orthogonal Polynomials*. Expo. Math. **33** (2015), 308-352.

[4] X. Yu, Z. Wang and H. Li, *Jacobi Sobolev orthogonal polynomials and spectral methods for elliptic boundary value problems*, Comm. Appl. Math. Comput. **1** (2019) 283-308.