"Doctoral Day" Programme–20 January 2023

Date and time: Friday 20 January
Venue: Conference Room ("Salón de Grados"), Mathematics Building (2nd floor)

08:50-09:00.- Welcome
Joaquín Gómez Camacho, Programme Coordinator, Universidad de Sevilla,
Antonio Prados Montaño, Academic Commmittee Member, Universidad de Sevilla

09:00-10:00 Opening Talk

When control theory meets physics

Prof. David Guéry-Odelin, Université Paul Sabatier, Toulouse, France

The field of control is often studied in engineering or applied mathematics. Curiously, it is little or not present in the training of physicists. Yet the laws of physics are found by functional minimizations, and the history of atomic physics is, for example, fueled by the increasing control that physicists have gained through technological developments in their own community.

In this talk on the growing role of control in modern physics, we will focus exclusively on examples of open-loop control. The objective here is most often to accelerate a physical transformation. While we will first propose some very simple examples of control, we will then present some ideas developed in the framework of a new branch of control, initially developed to answer some problems in quantum physics, the shortcuts to adiabaticity. These methods are essentially not defined with respect to a functional to be minimized, but they can be adapted to meet such constraints. Alternatively, optimal control theory built around a cost function also proves to be a fruitful approach for some specific tasks. We will provide examples from classical mechanics, statistical and quantum physics involving a wide variety of different types of model equations including ordinary and partial differential equations, stochastic differential equations... It is interesting to note that control theory allows the generation of exotic quantum states that cannot be produced by other means, thus opening new perspectives for quantum simulation. We will present some concrete examples. Eventually, control theory can be combined with quantum information theory, a new branch of control with applications in metrology.

David Guéry-Odelin's Short CV:

David Guéry-Odelin is a French physicist. He studied at École Normale Supérieure, and did his Ph.D. thesis under the supervision of Prof. Jean Dalibard in the ENS Physics department on quantum gases. In 2011, he published, with the Physics Nobel Prize Claude Cohen Tannoudji, a book on the advances in atomic physics. In 2013, David Guéry-Odelin was awarded the Servant Prize of the French Academy of Sciences. He was a CNRS junior researcher at Laboratory Kastler Brossel before joining the University of Toulouse III Paul Sabatier as a full professor. He is a former member of the Institut Universitaire de France. He leads an experimental team for the manipulation of cold atomic quantum gases for quantum sensing, simulation and calculation, and develops, for the theoretical part of his research, various control tools for classical, statistical and quantum physics.

Google Scholar profile

Morning Session

Date and time: Friday 20 January, 10:00-13:20
Venue: Conference Room ("Salón de Grados"), Mathematics Building (2nd floor)

Students' presentations

10:00-10:20.- Alvaro Saiz Castillo: "Machine learning analysis of Quantum Phase Transitions"

Abstract: Quantum computing and quantum simulations are a promising future for the study of naturally quantum systems, as well as solving previously intractable problems. Nonetheless, current quantum simulators bear strong limitations due to the difficulties of accurately and efficiently preparing, evolving and measuring quantum states. Therefore, it is of great interest to be able to extract as much information with as little resources as possible. In this talk, we will introduce a novel approach to Quantum Phase Transitions (QPT) study making use of classical machine learning methods to characterize the quantum phases of known models. This approach is accurate, robust against errors, independent of qubit size and is a first step into QPT prediction for unknown systems.

10:20-10:40.- José Rueda Rueda: "New generation of fast-ion diagnostics in Tokamaks"

Abstract: Characterization of the fast-ion transport and response to perturbation is essential for future fusion power plants, as loss of these particles can threat the viability of reactors. To this end, a new Imaging Neutral Particle Analyser has been developed and installed in the ASDEX Upgrade Tokamak. This new diagnostic allows, for the first time at ASDEX, the measurement of energy resolved fast-ion profiles with high resolution and fast temporal response.

The detector working principle will be presented, together with the state of the art analysis tools applied to determine the transport of fast-ions in phase space, such as tomographic reconstructions.

10:40-11:00.- Javad Gorji: "Bandpass delta-sigma modulators with FIR feedback"

Abstract: Bandpass delta-sigma modulators (BP-$\Delta\Sigma$Ms) digitize signals placed in an arbitrary band by applying a band-stop filtering to the quantization noise, so that it is pushed out of a given bandwidth, around the signal center frequency. One of their main applications is to digitize radio-frequency (RF) signals in wireless receivers, thus moving the analog-to-digital converter (ADC) closer to the antenna. This way, most of the signal processing—such as frequency down conversion, channel selection and image-reject filtering—can be implemented in the digital domain, thus benefiting from technology downscaling and higher programmability. As RF ADCs need sampling frequencies in the GHz range, state-of-the-art BP-$\Delta\Sigma$Ms are dominated by continuous-time (CT) circuits. CT-$\Delta\Sigma$Ms are potentially faster than their discrete-time (DT) counterparts while consuming less power as well as implementing inherent antialiasing filtering. A single-bit quantizer, i.e., a simple comparator, is sometimes chosen since multi-bit quantization in-

creases the hardware complexity and dynamic requirements in GHz-clocked BP-ΔΣMs. The full-scale feedback waveform, on the other hand, makes the system very sensitive to clock jitter. Another disadvantage of single-bit operation is the higher sampling frequency necessary to achieve the desired signal to quantization noise ratio (SQNR). This presentation proposes to address these problems using bandpass FIR feedback.

11:00-11:20.- Pablo Jiménez Fernández: "A novel design methodology for low-power, low-noise LC-based digital-controlled oscillators"

Abstract: This work presents a design methodology for LC-based oscillators that optimizes the phase noise/power trade-off. The proposed methodology takes into account from early design stages the effects of the degradation of the quality factor of both the inductor and varactors. Based on this, the limits of the design space and the minimum power consumption that fulfill targeted specification are determined. This methodology has supported the design of a 26.6-GHz digital-controlled oscillator. In addition, a chain of dividers has been developed to accommodate the off-chip signal.

11:20-11:50.- COFFEE BREAK

11:50-12:10.- Antonio Patrón Castro: "Optimal convergence time for the Metropolis algorithm"

Abstract: Markov Chain Monte Carlo techniques are among the most versatile and efficient ones in tackling myriads of problems in science that involve computational power. Here, within the Metropolis scheme, we analyse the optimisation problem of finding its minimum convergence time towards the steady state solution as a function of the characteristic length of the attempted jumps defining the random walk. Using different physical systems and classes of jump-distributions we show that optimality is achieved as a trade-work between the two competing forces governing the dynamics of the random walk: diffusion and rejection. Finally, further open problems and current work are outlined.

12:10-12:30.- Eusebio J. Rodríguez: "Observable consequences of curvature in spintronic circuits"

Abstract: We study the response of spin carriers to the effective field textures developed in mesoscopic curved one-dimensional circuits in two-dimensional electron gas (2DEG) subject to the action of several different spin-orbit interactions configurations: One Rashba spin-orbit coupling (SOC) configuration, one Rashba and Dresselhaus [001] (SOC) and one Dresselhaus [110] under the effect of an external Zeeman field. We show how the interplay between these fields and the circuit's geometry—triggered by vertices acting as spin-scattering centers— leads to observable consequences in the localization of the electronic wave function and the suppression of the quantum conductance, which are connected to the gathering of quantum spin-phases and can be interpretated topologically in terms of winding numbers.

12:30-12:50.- Gregorio García Valladares: "Buckling in a rotationally invariant spin-elastic model"

Abstract: Scanning tunneling microscopy experiments have revealed graphene sheets change their shape from a rippled (or flat) profile to a buckled profile when is heated in absence of any mechanical load—similarly to the mechanical phase transition studied in mechanical engineering known as Euler's buckling.

Several theoretical models relying on interaction between elastic and electronic degrees of freedom have been proven quite useful in order to understand the emergence of this interesting transition. Nevertheless, those previous models present unphysical symmetry breaking. We have developed and analysed an alternative classical spin-elastic model that preserves rotational invariance. Specifically, we have thoroughly derived and described in our new model the emergence of different mechanical phases, as well as their thermodynamic stability. The curvature of the system plays a central role, which is computed both analytically and numerically for the one and two-dimensional cases. In the latter, the focus is put on the honeycomb lattice, which is representative of actual graphene.

Flash Talks

12:50-12:55.- Ignacio María Delgado Lozano: "Stacked double patch microstrip antenna de-embedding of circuit parameters based on least squares method"
Abstract: This work retrieves the unknown parameters of lumped elements in equivalent circuits from simulated scattering parameters of a stacked double patch microstrip antenna. To complete this task, the equivalent circuit for the studied antenna is built based on the geometrical and electrical aspects from the antenna system. After that, using the simulated antenna response, we retrieve the unknown circuit parameters using two fit models based on the least squares and the total least squares method.

12:55-13:00.- Hamidreza Erfanijazi: "RRAM characterizing with multiple bits per device using pulse width modulation"
Abstract: One of the issues facing neuromorphic engineering is increasing memory capacity in a limited space with minimal power consumption. Creating analog memories with memristive devices that mimic the brain's synapsis has evolved into a potential approach for reaching this aim over time. By using pulse width modulation, we introduce a novel technique for adjusting the conductance of analog RRAMs while maintaining the stability of other parameters with endurance against relaxation effect.

13:00-13:05.- Andrés Santana: "Failure mechanisms in integrated circuits"
Abstract: Characterizing and modelling the sources of failures in integrated circuits is a key field of research for circuit design. These failure mechanisms can be classified according to their origin and their nature. Some of them are better modelled and incorporated to the design flow while others are not well understood. Our research focuses on parametric degradation of circuits, which are particularly challenging to model due to their stochastic nature.

13:05-13:10.- Servando Marín Meana: "Atmospheric pressure gliding-arc plasmas for sustainable applications"
Abstract: This PhD thesis deals with the development of atmospheric pressure plasmas that use electricity as energy vector to carry out chemical processes that are usually addressed by catalytic techniques (ammonia synthesis, CO2 removal) that involve high temperatures, low yields, and unwanted subproducts. With this aim, we will build and characterize, both experimentally and theoretically, a gliding arc plasma reactor offering

an eco-friendly alternative to substitute those conventional catalytic techniques by purely physical processes.

13:10-13:15.- Manuel Jiménez Través: "Enabling energy-efficient brain-inspired computation with hardware Oscillatory Neural Networks"

Abstract: Edge Computing and Internet-of-Things face computationally hard problems that requires energy-efficient solutions. Oscillatory Neural Network (ONN) mimics extremely energy-efficient, parallel and collective brain computation using VO2-based oscillators as neurons and memristors as synapses. Developed work targets to cover different stages in the study and design of hardware ONN which includes development of different demonstrators (digital and analog) as proof-of-concept as well as different learning techniques and the search of suitable applications.

13:15-13:20.- José Luis Medrán del Río: "Monolithic bandpass filter based on intertwined helical resonators"

Abstract: Brief introduction to results obtained during an international stay at Tyndall National Institute in Cork. The topic will be the development of a single-ended single band bandpass filter based on a monolithic integration of intertwined helical resonators inside a hollow cavity. A prototype has been manufactured to verify the proposed concept and topology.

13:15-13:20.- LUNCHTIME

Afternoon Session

Date and time: Friday 20 January, 14:50-16:55
Venue: Conference Room ("Salón de Grados"), Mathematics Building (2nd floor)

Students' presentations

14:50-15:10.- José Luis García León: "Detection and measurement of radionuclides. The case of 55Fe and 63Ni"

Abstract: Liquid scintillation counting (LSC) is a spectrometric technique used for determining the activity of electron-emitting radionuclides. This is the case of 63Ni and 55Fe, which decay by beta emission and electron capture respectively. In this work, a liquid scintillation spectrometer, named Quantulus 1220, is studied and adapted for 63Ni and 55Fe measurements. The optimisation of work conditions in a liquid scintillation spectrometer considers the type of vial, the scintillator, the aqueous solution, and the sample/scintillation volume ratio. For that, a high number of radioactive samples have been involved to obtain enough information and determine the optimal counting conditions. Finally, the most important parameters in low-level counting by LSC (counting efficiency and lower limit of detection) were extensively determined in different situations. LSC is deeply affected by the so-called quenching (a decrease of counting efficiency due to the presence of chemical or colorant agents in the counting vial), which has been studied in this work. As this technique might be used for environmental (low-level) measurements, a spectrum analysis technique that optimizes the lower limit of detection is developed. Determination of the activity concentration of 55Fe and 63Ni is critical for decommissioning nuclear power plants due their presence in radioactive waste.

15:10-15:30.- Rafael de la Rosa Vidal: "PixiStamp, a tool to acquire, process and sequence AER data from event-driven systems"

Abstract: We present a new tool, PixiStamp, to readout, process, and sequence data of event-driven systems that exchange data using the AER protocol. Typically, asynchronous sensor data is conveyed off-chip using the well-known Address Event Representation (AER) protocol. There are multiple pixels (or cells) that are autonomous and transmit their coordinates through a shared bus using a handshaking protocol. Thus, the number of wires is minimized and the operation is fully asynchronous, assuring high-speed readout operation. In addition to specific in-pixel circuitry, this particular protocol requires dedicated peripherals to communicate with and exchange data. PixiStamp is a compact acquisition board that can be easily attached to other devices. Over other existing solutions, it has enhanced hardware processing capabilities to process AER data and generate control signals after data processing, making possible a closed-loop device control. The talk will describes in detail the system architecture, its mechanical design, and its main features.

15:30-15:50.- Daniel Suárez García: "Determination of domain sizes in the context of the Microdosimetric Kinetic Model for different cell lines based on in vitro experiments"

Abstract: The Microdosimetric Kinetic Model (MKM) postulates the concept of domain as representing the maximum distance for sublethal lesions to pairwise interact to form a lethal lesion. The domain is associated with the maximum distance two sublethal lesions may travel to interact and lead to cell death. In this presentation, we have explored the Particle Irradiation Database Ensemble (PIDE) from the GSI, analyzing different experiments with protons and alpha particles to obtain the statistical distribution of values for the domain sizes for the MKM corresponding to different cell lines. This is supposed to illustrate the difference in radiosensitivity across biological systems, which calls for a variable parameter adaptable to each system in the MKM. Additionally, a dataset of values for diverse cell lines is provided.

15:50-16:10.- Eros Camacho: "Microelectronic design of a hardware Root of Trust (RoT) robust to aging"

Abstract: Modern digitalization is bringing enormous benefits to society and the economy, such as the development of connected and autonomous vehicles. This is known as the Internet-of-Things (IoT). However, it must be ensured that these devices are reliable over time while remaining secure, which requires the use of cryptographic solutions to protect them against possible attacks. To this end, encryption/decryption algorithms are provided so that only the authorized user with the key can access the information, as well as unique device identification solutions. This whole approach has only recently begun to be addressed from a purely hardware perspective. The solution emerges through the design and use of a Root of Trust (RoT) to increase the security of a particular device. On the one hand, the security of key exchanges is improved by post-quantum cryptographic implementations in hardware modules. On the other hand, the use of unique digital identifiers generated from unclonable physical functions (PUFs) is exploited. These two solutions should be invariant with time of use, while occupying relatively little space.

16:10-16:30.- Joël François Tsoplefack: "Scattering of solitons on a localized impurity in the discrete nonlinear Schrödinger equation with a saturable nonlinearity"

Abstract: We study numerically the interactions between solitons and a localized impurity in the discrete nonlinear Schrödinger equation with a saturable nonlinearity. For different values of the soliton frequency ranging from ω=0.1 (large amplitude) to ω=0.9 (small amplitude), we determine as a function of impurity strength and soliton initial velocity, the regions of trapping, reflection and transmission. We observe that as the soliton frequency increases from 0.1 to 0.3, the trapping region becomes larger, and when it increases from 0.4 to 0.9 the trapping region becomes narrower. We show that for large amplitude solitons and specific values of impurity strength and soliton initial velocity, irregular phenomena such as trapping and double reflection, trapping and double transmission, and double trapping with simple transmission followed by simple trapping and double transmission can occur.

Flash Talks

16:30-16:35.- Samira Baid: "Analytical solutions of the Bohr Hamiltonian with the sextic oscillator: PT-OS isotopes"

Abstract: The lower collective quadrupole states in even nuclei are studied for the special case of γ-unstable potential in Bohr Hamiltonian. Particularly, the quasi-exactly soluble β-sexticpotential is extended to describe the even isotopes of Pt and Os. This study aimed toinvestigate the possible transition between the γ-unstable and spherical vibrational phases.The energy eigenvalue and electrical quadrupole transitions B(E2) are calculated in a closedanalytical form and compared with experimental data.

16:35-16:40 Jesús González Rosa: "Study of inelastic procceses using the superscaling approach"

Abstract: The superscaling SuSAv2 model, that was successfully used to explain electron scattering data in the quasielastic (QE) as well as in the high inelastic regions is here extended to charged-current neutrino scattering processes on nuclei (resonant, non-resonant and deep inelastic scattering). We study the resonance region using ienlastic structure functions from the Dynamical Coupled Channels model (DCC). Our predictions are compared with T2K data results.

16:40-16:45.- Yimo Zhang: "Transient oscillation response characteristics of an electrohydrodynamic settling drop subjected to a uniform electric field"

Abstract: The transient oscillation response of an electrohydrodynamic settling drop under a uniform electric field is numerically investigated. The governing equations are solved in the lattice Boltzmann framework through the application of the leaky dielectric model and the pseudopotential model for the multi-phase electrohydrodynamic problem. A viscous drop with inertia is considered for non-density matched settling systems. Numerical simulations are performed over a range of electric capillary numbers CaE, Eotvos numbers Eo, and Ohnesorge numbers Oh.

16:45-16:50.- Qi Wang: "Numerical analysis on transition sequence and heat transfer capacity of film boiling with a uniform electric field"

Abstract: The film-boiling scenario with the influence of electric fields is numerically analyzed. For an overheated temperature of ΔT=5, 10, 20K, the system exhibits a quasi-periodicity sequence, an alternate periodic-chaotic sequence, and a periodic-chaotic sequence. The results show that the vertical electric field can improve the heat transfer capacity by elongating the bubble, accelerating the bubble release frequency, and promoting the system from film boiling to nucleate boiling. The maximum heat transfer enhancement ratio is 4.84.

16:50-16:55.- Pablo Pérez Maroto: "How to measure neutron capture cross sections"

Abstract: Nowadays there are two methods to measure a neutron capture (n,γ) cross section: the time-of-flight technique and the activation technique. In this flash talk we are going to explain very briefly the two methods, see the differences between then and show real examples of neutron capture measurements performed by the Universidad de Sevilla in collaboration with international facilities like CERN.

Attendees (without talk):

- Iván Díez De los Ríos Luis
- Farnaz Faramarzi
- Pablo Fernández Peramo
- Agustín Fernández Rueda
- Lucas Garrido Gómez
- Apurba Karmakar
- Victoria Lérida
- Antonio Jesús López Fuentes
- Alessio Mancini
- Servando Marín Meana
- Manuel Mayo León
- Roberto José Méndez Romero
- Kourosh Mokhtari
- Pedro Punta de la Herrán
- Natalia Ruiz Pino
- Darío Sánchez Jiménez
- Virginia Zúñiga González

TIMETABLE

Venue: Conference Room ("Salón de Grados")
Mathematics Building (2nd floor)

	Morning Session		**Afternoon Session**
08:50-09:00	**Welcome**	13:20-14:50	LUNCHTIME
09:00-10:00	**Opening talk** **Guéry-Odelin**		
	Students' presentations		**Students' presentations**
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10:20-10:40	Rueda	15:10-15:30	De la Rosa
10:40-11:00	Gorji	15:30-15:50	Suárez
11:00-11:20	Jiménez	15:50-16:10	Camacho
11:20-11:50	COFFEE BREAK	16:10-16:30	Tsopleface
11:50-12:10	Patrón	16:30-16:55	FLASH TALKS
12:10-12:30	Rodríguez		
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12:50-13:20	FLASH TALKS		