"Doctoral Day" Programme–7 July 2023

Date and time: Friday 7 July
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

The first thirty years of Nanophotonics: a personal journey

Prof. Francisco José García Vidal,
Universidad Autónoma de Madrid

Abstract: During the last thirty years, a new area of research within Physics has emerged, aiming to control the flow of light at length scales of the order or even smaller than the wavelength. This new frontier is named Nanophotonics and has become an interdisciplinary field of research that combines expertise from Condensed Matter Physics, Classical and Quantum Optics and Materials Science. The basic idea of Nanophotonics is to tune the material properties of the medium in which light flows to devise its propagation at will. To frame our own research, in the first part of my talk I will briefly introduce the three main developments that have emerged in Nanophotonics during these thirty years: Photonic Crystals, Plasmonics and Metamaterials.

The main part of the presentation will be devoted to describing two main findings achieved in our theoretical group in this field of research: the phenomenon of the transmission of light through subwavelength apertures [1] and the concept of spoof surface plasmons [2]. First, we will show how surface plasmons can be utilized to overcome the two main limitations that diffraction imposes to light when passing through subwavelength apertures: low transmission and propagation into all directions. Next, we will

discuss how structuring metallic surfaces allows for the support of surface electromagnetic modes at low frequencies that mimic the behavior of surface plasmons at optical frequencies. We will also illustrate how these spoof surface plasmon modes can be used in applications that require the manipulation of electromagnetic fields at microwave and terahertz frequencies.

Finally, we will briefly show how light-matter interaction can be used not only to control light propagation as classical Nanophotonics does but, by taking advantage of the quantum hybrid nature of the polaritons formed when light-matter coupling is strong enough, to modify material and chemical properties by tailoring vacuum electromagnetic fields [3].

[1] F. J. García-Vidal et al., Reviews of Modern Physics **82**, 729 (2010).
[2] F. J. García-Vidal et al., Reviews of Modern Physics **94**, 025004 (2022).
[3] F. J. García-Vidal, C. Ciuti, and T. W. Ebbesen, Science **373**, eabd0336 (2021).

Francisco José García Vidal's short CV:

F. J. García Vidal graduated (1988) and obtained a PhD degree (1992), both in Physics, from Universidad Autónoma de Madrid (UAM). He was a Marie-Curie Fellow at Imperial College of London (1994-96) working with Prof. Sir John Pendry. Since then, he has been associated with the UAM as Associate Professor and Full Professor (2007) (Condensed Matter Physics Center – IFIMAC, which is a Maria de Maeztu Unit of Excellence). He is the leader of an internationally renowned theoretical research group dedicated to investigating the exciting possibilities of Plasmonics, Metamaterials and Nanophotonics. This group has collaborated with the most relevant experimental groups working in those fields. Prof. Garcia Vidal has been the PI of more than 15 Spanish and European Grants, including a prestigious Advanced Grant from ERC (2012). Since March 2017, Prof. Garcia Vidal serves as Divisional Associate Editor in the journal Physical Review Letters (APS). He was selected as Fellow of the Optical Society of America in year 2020, was awarded by the Jaume I Prize in the category of Basic Research in the same year and has been also awarded with Blas Cabrera National prize in Physics in year 2021. He has also been selected six times among the most influential physicists of the decade (2014, 2015, 2017, 2019, 2020 and 2021) by Thomson Reuters.

Professional web page

Morning Session

Date and time: Friday 7 July, 10:00-13:50
Venue: Conference Room ("Salón de Grados"), Mathematics Building (2nd floor)

Students' presentations

10:00-10:20.- Farnaz Faramarzi: "Electronically Foveated Vision sensor"

Biological vision systems lack the concept of frames, unlike artificial vision systems. Neuromorphic vision sensors offer a biologically inspired alternative, generating spatio-temporal representations of visual scenes through spikes per sensing pixel. These spikes encode the spatio-temporal visual contrast, avoiding redundant information for static low contrast areas. High contrast moving parts generate spiking output activity, saving power and bandwidth. Some sensors provide high temporal resolution, preserving spatio-temporal position information for fast-moving objects. Dynamic vision sensors (DVS) respond to relative temporal changes in illumination. With megapixel resolution, temporal resolution is limited by sensor output bandwidth. Efforts have focused on enhancing bandwidth and reducing spatial/temporal redundancy in events. This project proposes an electronically foveated dynamic vision sensor as a core component for compact visual systems. Electronic foveation allows dynamic resource allocation to regions of interest. By optimizing computational resource allocation, it enhances efficiency and addresses real-time processing challenges in handling large amounts of visual data.

10:20-10:40.- Pablo Oyola Domínguez: "Validation of the synthetic model for the imaging Heavy Ion Beam Probe"

Abstract: First measurements with the imaging Heavy-Ion Beam Probe (iHIBP) have been obtained at the ASDEX Upgrade tokamak. In this work, we will compare these results against the synthetic diagnostic model, i-HIBPsim, where the code evolves the heavy-ion beam through the plasma, until it reaches a scintillator plate. The light pattern emitted by the scintillator contains relevant information on the plasma, such as the magnetic field orientation, the electrostatic potential and plasma density close to the plasma edge. To capture the full complexity of the problem, the synthetic code has been upgraded to include a realistic finite beam model, beam divergence and a 3D-model of the optical head. The optical model, including distortion and magnification, has also been including allowing a one-to-one comparison of the synthetic signals to real signals. Dedicated plasma experiments were carried out at the ASDEX Upgrade, consisting on plasma ramps, that translate into changes into the pattern, that could be reproduced with the synthetic model for all the currents. Implementation of the signal inversion, this is, unfolding the real signal into a physical property is also possible in the new framework, where first density measurements have been obtained and are in reasonable agreement with other diagnostics.

10:40-11:00.- José Antonio Pavón Rodríguez: "Preliminary Evaluation of the neutron energy flux for the n_TOF-EAR2 facility at CERN"

Abstract: The n_TOF Collaboration operates the neutron time-of-flight facility at CERN.

The neutron source consists of a lead target irradiated by a 20 GeV/c pulsed proton beam. It comprises two experimental areas, EAR1, located at 185 m from the spallation target, and EAR2, located at 20 m above the target. During CERN's second long shutdown (2019-2020), the facility has gone through a major upgrade, including the installation of a new spallation target.

In a commissioning phase carried out in 2021, the changes in the neutron energy flux for the new spallation target with respect to the previous operational phase were investigated. The characterisation of the neutron flux required the combination of a series of measurements, making use of several detection systems such as micro-megas, parallel plate avalanche counters and silicon monitors, with diverse neutron-converting reactions considered standard in different energy regions. The preliminary evaluation of neutron flux resulting from the measurements in EAR2 as well as a comparison to extensive Monte Carlo simulations with the FLUKA code will be presented.

11:00-11:20.- Iván Díez de los Ríos Luis: "Signal pre-processing for memristor-based neuromorphic computing for epileptiform signals in spheroids"

Abstract: Brain tissue regeneration is one of the hardest challenges. In the Hermes project, we are looking for a biohybrid solution using bioengineered brain tissue, neuromorphic microelectronic and artificial intelligence. A Neuromorphic Computation System (NCS) guides the bioengineered brain tissue to prevent seizures. In this presentation, we explore a memristor-inspired computation method for epileptiform activity generated by rodent hippocampal spheroids. This method provides us with a kind of "spectrogram" or "fingerprint" implementable in the NCS. It can be used to compute on the fly and with low computational cost an alert-level signal for epileptiform events onset. Here, we describe the computational method behind this "fingerprint" technique and illustrate it using epileptiform events recorded from hippocampal spheroids using a microelectrode array system.

11:20-11:40.- Pedro Barba Lozano: "ADC Architectural Study for Digitally-Assisted Multi-Gigabit Data Communication Transceivers "

A methodology for comparing both Successive Approximation Register (SAR) and pipeline-SAR Analog-to-Digital Converter (ADC) architectures based on a target Equivalent Number Of Bits (ENOB) is presented. First, a system-level model is used to select the parameters needed to achieve a given ENOB. Then, the power consumption of the solution is estimated. Finally, the different architectures are compared based on that estimation. A sample rate of 25GHz, 7 bits of ENOB and a metastability probability of 10^{-12} have been used as a reference considering the requirement for a 4-level Pulse Amplitude Modulation (PAM-4), 25Gbps ADC-based transceiver. A design space for these specifications has been obtained.

11:40-12:10.- COFFEE BREAK

12:10-12:30.- Rubén Gómez Merchán: "Low-latency Low-power Sun Sensor using Photovoltaic-mode Photodiodes"

Abstract: This talk introduces a new concept of sun sensor using photodiodes working as solar cells. Dedicated logic is implemented to calculate the centroid position which results in lower latency and energy consumption. This architecture overcomes conventional approaches in terms of latency, power consumption and data throughput. The output

data flow is significantly reduced since the only data output of the sensor is the centroid of the illuminated pixels. The latency of the proposed sensor is in the order of microseconds, while its average power consumption is 63 μW. Experimental results are provided and compared.

Abstract: 12:30-12:50.- Natalia Ruiz Pino: "Feedback flashing ratchets: the role of information and entropy reduction"

Abstract: Flashing ratchets are dynamic systems that generate directed motion against external forces by switching on and off a periodic potential. This motion arises from the alternating effects of the potential's action and free diffusion. The switching protocol can be classified into two types: open-loop, which lacks sys- tem information, and feedback, which employs extracted information to update the potential state. Our study focuses on a feedback flashing ratchet system comprising an overdamped Brownian particle and an external control that periodically measures the particle's position. The control system employs this infor- mation to switch on and off a sawtooth-periodic potential. The measurement process induces a reduction in the particle's entropy, leading to a concentration of the probability distribution within microstates consistent with the measurement outcome. Overlooking this entropy reduction results in an overestimated system efficiency, known as open-loop efficiency, greater than one. Our goal is to quantitatively analyze the entropy reduction and explore its dependence on system parameters. By doing so, we aim to gain insights into the role of information in the energetic balance of the system.

12:50-13:10.- Darío Sánchez Jiménez: "The challenge of the determination of 36Cl by the 1 MV Accelerator Mass Spectrometry facility"

Abstract: In general, radiometric techniques have serious limitations for the analysis of long-lived radionuclides such as 36Cl (T1/2 = 0.3 My, β- emitter). The main challenge facing Mass Spectrometry techniques (MS) is the suppression of its isobaric interference, the naturally occurring 36S (i.e., 0.02% isotopic abundance). At the Centro Nacional de Aceleradores (CNA, Sevilla) we are exploring the limits of the 1 MV Accelerator Mass Spectrometry (AMS) system facility for its analysis. Compact AMS systems prevent isobaric suppression techniques based on the difference in stopping power between Cl and S, thus, the sulphur content in the samples must be reduced by radiochemical means, and the occurrence of 36S counts during the detection of 36Cl must be controlled by measuring the 33S count rates and extrapolating the corresponding ones to 36S assuming the natural 36S/33S isotopic ratio. Tests on blank samples (i.e., 36Cl/Cl $\leq$ 10-14) have shown a limiting 36S/Cl background of 10^{-9}, which is competitive for the determination of anthropogenic 36Cl in nuclear waste samples. An intercomparison exercise was carried out at the 6 MV ETH Zurich AMS facility. The obtained results show that the main limitation is due to the presence of sulphur in the AMS cathode components.

13:10-13:30.- Pedro Punta de la Herrán: "Deformed two-body models for exotic nuclei"

Abstract: Light exotic nuclei can be conveniently described using few-body models. However, in some cases, possible deformations of the clusters need to be considered. This is the case of the exotic nuclei ^{11}Be or ^{17}C, which display a marked core+neutron structure and the core fragment has a large quadrupole deformation.

In this work, the structure of these nuclei is described using two-body models where a neutron moves under the action of a deformed potential generated by the core. Two dif-

ferent models have been used: Nilsson and semi-microscopic particle-plus-AMD (PAMD) model from Phys. Rev. C 89 (2014) 014333. Energies and associated wave functions are obtained by diagonalizing the Hamiltonian in a transformed Harmonic Oscillator basis (THO). This basis has been successfully applied to the discretization of the continuum of two-body and three-body weakly bound nuclei.

The structure models are tested by studying transfer reactions ^{11}Be(p,d)^{10}Be and ^{16}C(d,p)^{17}C. Good agreement is found for these transfer reactions to bound states by comparing with the experimental data from Chinese Phys. Lett. 35 (2018) 082501, Phys. Lett. B 811 (2020) 135939, respectively.

13:30-13:50.- Antonio Jesús López Fuentes: "Characterization of natural and anthropogenic radionuclides in sediment cores from the Black Sea using AMS and high resolution gamma spectrometry"

Abstract: Novel results on anthropogenic Pu, U, ^{137}Cs and natural (^{238}U and ^{232}Th series) isotopes in sediment cores, collected at the north-western Black Sea, are presented. The samples were analysed on the 1 MV AMS system at CNA and the Gamma Spectrometry analysis were performed using an extended range (XtRa) HpGe detector at the Faculty of Physics. Very scarce literature has been published about anthropogenic actinides radionuclides in Black Sea sediments. To the best of our knowledge, information on the Pu isotopic composition (i.e., ^{240}Pu/^{239}Pu) and ^{236}U is lacking, which are essential radionuclides to elucidate the influence of the Chernobyl accident in the region. The sediment cores have been dated using the ^{210}Pb allowing the temporal reconstruction of the Pu and ^{236}U fingerprint in the area. This results are complemented with information on ^{137}Cs, also obtained by gamma spectrometry. The cores, sampled between 250 and 1000 m depth and with a length of 10 cm, were provided by the National Institute of Physics and Nuclear Engineering Horia Hulubei. Preliminary results point out to the existence of additional sources other than Chernobyl accident, with ^{240}Pu/^{239}Pu atom ratios below the expected ones for Global Fallout.

13:50-15:20.- LUNCHTIME

Afternoon Session

Date and time: Friday 7 July, 15:20-17:00
Venue: Conference Room ("Salón de Grados"), Mathematics Building (2nd floor)

15:20-15:40.- Ignacio María Delgado Lozano: "Wideband stacked rectangular patch antenna design in S, C, and X bands through lumped element filters using single-ended and differential feeding"

Abstract: In this work, we propose a systematic methodology to design broadband stacked patch microstrip antennas based on a known quasi-Chebyshev second order bandpass filter response. The antenna behaviour is modelled through an equivalent circuit formed by a LC series resonator that represents the feed and two capacitively coupled LC parallel resonators that stand for the rectangular stacked patches. The parameters of this equivalent circuit are retrieved using a numerical de-embedding procedure based on the least squares method plus an optimization procedure. Using this methodology, the authors have been able to design three antennas in different frequency bands (S, C and X) with fractional bandwidths superior to 30%. Moreover, this work establishes a clear relation between the geometrical and physical aspects of the antenna and its circuital counterparts, which enables an optimal fit in order to obtain well matched broadband antennas. Finally, we make the necessary changes in these single- ended antennas to adapt them to a differential feeding operation mode.

15:40-16:00.- Yimo Zhang: "Evolution of capillary jets with sinusoidal and modulated Gaussian perturbation "

An improved velocity measurement method for capillary jets is presented by imposing the sinusoidal pressure disturbances at the exit chamber. From the relation between the flow rate and jet velocity, a mean jet radius is obtained as well as the Weber number, the Ohnesorge number and the theoretical optimal wave number corresponding to the maximum growth rate of the classical Rayleigh dispersion relation under specific flow conditions. Also, the spatial evolution of Gaussian wave packets in cylindrical capillary jets is experimentally explored in terms of the Gaussian-shaped wave number, bell width, and amplitude. These parameters show a similar manner to those predicted by the temporal analysis.

16:00-16:20.-Samira Baid: "Spectroscopic Properties and Shape Coexistence in Ru and Mo Isotopes"

This study investigates the spectroscopic properties of Ru and Mo isotopes, with a focus on shape coexistence. By utilizing the interacting boson model, the researchers calculate various observables and compare them to experimental data. The results demonstrate good agreement between theory and experiment. Specifically, the study finds that shape coexistence plays a significant role in Mo isotopes, where the crossing of intruder and regular configurations occurs at neutron number 60 ($A = 102$). In contrast, the influence of intruder states in Ru isotopes is minimal, as they remain at higher energies. The findings shed light on the behavior of these isotopes as they deviate from the sub-shell closure. This research contributes to our understanding of shape coexistence and its impact on the spectroscopic properties of Mo and Ru isotopes. Overall, this study provides valuable insights into the nuclear structure of these isotopes and offers a framework for further investigations in the field of nuclear physics.

16:20-16:40.- Virginia Zúñiga González: "A security comparison between AES-128 and AES-256 FPGA implementations against DPA attacks"

Abstract: Users store their private data daily on electronic devices making use of cryptography to ensure data confidentiality. These cryptocircuits implement mathematically secure algorithms, but because of their physical implementation, they leak information (power, timing, EMI, etc.) that could be used by third parties to reveal private data, through side-channel attacks (SCAs). For this reason, the generation of hardware identity, the development of secure encryption mechanisms with low resources, and the protection of systems against SCAs have been a very active research field in the TIC-180 group of the IMSE, in which this Thesis is intended to be developed. AES, the standard symmetric cipher selected by NIST, is the best-known and most widely used block cipher. Consequently, security threats are constantly rising and increasingly powerful. With the addition of the upcoming scenario of quantum computing, these threats have become a front-line concern in the crypto-community. Although is claimed that using larger key sizes than 128 bits in symmetric key algorithms for implementing quantum-resistant implementations is enough to counteract brute force attacks, both AES-128 and AES-256 are vulnerable to Power Analysis attacks. We present a security comparison against Differential Power Analysis (DPA) attacks over both AES 128-256 through experimental attacks in FPGA.

Flash Talks

16:40-16:45.- Victoria Lérida Toro: "Alkaline method for determination of the 129I/127I isotopic ratio by AMS and ICP-MS"

Abstract: This ratio is an indicator of the 129I environmental contamination. In liquid samples, it is enough to take an aliquot of the sample to measure 127I by ICP-MS before processing it to measure 129I by AMS, but in solid samples, more complex processes to obtain a solution that contains the dissolved iodine in the right chemical form are needed. A radiochemical method based on an alkaline microwave leaching is proposed to allow the determination of 129I/127I.

16:45-16:50.- Pedro Martín Holgado: "Effects of Neutron Radiation on the Current Transfer Ratio of GaAsP and AlGaAs Optocouplers"

Abstract: This work presents the degradation of GaAsP and AlGaAs optocouplers as a result of the displacement damage produced by neutron radiation. The devices were irradiated using a (14.5 ± 0.4) MeV monoenergetic neutron beam on the Frascati Neutron Generator (FNG). In particular, the degradation of the Current Transfer Ratio (CTR) parameter is studied, and it can be represented as an exponential function of the fluence for the HCPL-5530, HSPL-5730, IBS-249, IHS-300, OLF-400, and OLS-300 optocouplers.

16:50-16:55.- Faustino Palmero Ramos: "Study of stability of a discrete double sine-Gordon system"

Abstract: The main aim of this work is to study the soliton ratchet phenomena in a discrete double sine-Gordon system. This system, which consists of coupled second-order ordinary differential equations (ODEs), is reduced to a system of just two coupled second-order ODEs by making use of the collective coordinate approximation. Using this simpler system, we study the stability of the periodic and travelling wave solutions using Floquet analysis.

16:55-17:00.- Qi Wang: "Numerical analysis on flow-focused DC/AC electrified jets "

Abstract: We conducted numerical simulations to investigate the flow-focused electrified jets to gain a better understanding of the physical characteristics. Our previous work qualitatively reproduces the phenomenon of jet elongation under the influence of an AC electric field. This work represents a further extension of our previous work. Both the DC and AC electric field conditions are investigated, and the corresponding results are compared qualitatively.

Attendees (without talk):

- Jesús José Domínguez-Palacios Durán
- Hamidreza Erfanijazi
- Juan Manuel Franco Patiño
- Javad Gorji
- Amir Khan
- Ramón López Cansino
- Paula López González
- Kiera Anne McKay
- José Luis Medrán del Río
- Mohammad Niazi
- María Laura Olivera Atencio
- Sergio Palomeque Mangut
- Roberto Román Hadjerek
- Alvaro Saiz Castillo
- Jesús Salas Suárez Bárcena

TIMETABLE

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

	Morning Session
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	Students' presentations
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13:50-15:20	LUNCHTIME
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16:40-17:00	Flash Talks