Doctoral Day Programme–26th June 2026

Date and time: Friday 26th June
Venue: ***Sala de Grados*, Mathematics Faculty (2nd floor)**

08:50-09:00 Welcome: Antonio Prados Montaño, Programme Coordinator, Universidad de Sevilla, Manuela Rodríguez Gallardo, Academic Commmittee Member, Universidad de Sevilla

09:00-10:00 Opening Talk: Dr. Teresa Kurtukian Nieto, Institue of Matter Structure (IEM)–CSIC

Presenting: Manuela Rodríguez Gallardo, Dpto. Física Atómica, Molecular y Nuclear

10:00-14:20 Students talks

8:50-9:00	Welcome
9:00-10:00	Opening talk
10:00-10:20	Fco. Javier Hidalgo Zamora
10:20-10:40	Dian Li
10:40-11:00	Brenda Pinheiro Carneiro
11:00-11:30	Coffe break
11:30-11:50	Alejandro Casado Galán
11:50-12:10	Joaquín Ceballos Cáceres
12:10-12:30	Bruno Fernández Sánchez-H.
12:30-12:50	Yanjin Lyu
12:50-13:10	Joseba Martínez Arrizabalaga
13:10-13:30	Stamatis Argyroudius
13:30-13:50	Shangyu Wang
13:50-14:10	Yaohui Lu
14:10-14:15	Daniel Téllez Calle
14:15-14:20	Juan Manuel Moreno Cenizo
14:20-14:25	Yassine Lamouaraa Sedlackova
14:25-14:30	Closing remarks

Dr. Teresa Kurtukian Nieto
Professor of Research
Institue of Matter Structure (IEM)–CSIC

From the Origin of the Elements in Stars to Particle Accelerators: My Personal Journey in Nuclear Astrophysics

Abstract: Nuclear astrophysics seeks to understand how the chemical elements are formed in stars and in the most energetic phenomena in the Universe. In this talk, I will present some of the main challenges associated with the study of stellar nucleosynthesis and discuss how particle accelerators allow us to reproduce and investigate in the laboratory processes that occur in the cosmos. Drawing on research carried out at major scientific facilities in France, Germany, and Japan, I will also share my personal and professional experiences, reflecting on the role of doctoral training, international mobility, and the opportunities offered by a research career in a global scientific environment.

Teresa Kurtukian Nieto's short CV: Teresa Kurtukian Nieto is a Research Professor at the Spanish National Research Council (CSIC) at the Institute of Matter Structure (Madrid) and a specialist in experimental nuclear physics and nuclear astrophysics. Her research focuses on the study of exotic nuclei and the nuclear reactions that occur in stars, which are essential for understanding the origin of the chemical elements in the Universe.

Throughout her career, she has developed an extensive international trajectory across Venezuela, the United States, Spain, Germany, France, and Japan, combining fundamental research in nuclear physics and astrophysics with the development of advanced scientific instrumentation. Her main contributions include studies of neutron-rich nuclei relevant to stellar nucleosynthesis, the development of novel experimental techniques for investigating radioactive nuclei, and the design of high-precision spectrometers and magnetic separators for major international research facilities.

Since 2021, she has served as Scientific Coordinator of the International Research Network ASTRANUCAP, promoted by the French CNRS. She is currently involved in experiments at ISOLDE-CERN, RIKEN (Japan), and GSI (Germany), while also contributing to the development of new technologies for particle accelerators, superconducting magnets, and advanced particle-detection systems.

Students Session

Date and time: Friday 26th June, 10:00-14:30
Venue: ***Salón de Grados*, Faculty of Mathematics (2nd floor)**

Long talks

10:00-10:20 Francisco Javier Hidalgo Zamora: *An enhanced method for determining the quadruple integrals arising in the spatial domain Method of Moments of multilayered periodic structures*

Abstract: This work proposes a method to reduce the number of numerical integrals from four to two in the computation of the reaction integrals for the spatial-domain Method of Moments (MoM) analysis of multilayered periodic structures with Rao-Wilton-Glisson (RWG) basis functions defined in a uniform triangular mesh. The results obtained indicate important CPU time savings can be attained when the novel approach is used. These results have been validated by comparison with both commercial software and previously published results for the unit cell of frequency selective surfaces and reflectarrays.

10:20-10:40 Dian Li: *Enhancement of the Condensation Process under Low Heat Flux Density Conditions via Electric Fields*

Abstract: Low-heat-flux condensation is relevant to compact water-recovery, humidity-control and thermal-management systems, where enhancement strategies should improve heat transfer, condensate removal, recoverable yield and auxiliary power consumption simultaneously. In this work, a tunable needle–plate non-uniform direct-current electric field is introduced into dropwise condensation on a vertical plate. A custom platform integrating high-definition visualisation, synchronous thermal/electrical measurements and split-drainage condensate weighing is developed to evaluate electric-field parameters, droplet evolution, centreline local heat flux, net condensate yield and electrical power input within a unified framework. The electric field markedly modifies droplet nucleation, growth, coalescence and departure, accelerates surface renewal and forms a persistent droplet-sparse/cleared region near the needle-tip-affected area under strong-field conditions. The maximum centreline local heat-flux enhancement reaches 66% under negative polarity at d = 5 mm and V = 5 kV. Considering heat-transfer enhancement, condensate yield and electrical power together, the best overall tested condition is negative polarity at d = 10 mm and V = 5 kV, requiring only 29 mW while increasing net condensate yield by 29% and centreline local heat flux by 63%. These results provide guidance for compact low-power condensation devices.

10:40-11:00 Brenda Pinheiro Carneiro: *Probing The Structure Of The Two-Proton Borromean Nucleus ^{17}Ne Through Inclusive Breakup Data*

Abstract: The proton-rich nucleus ^{17}Ne exhibits a Borromean structure, ^{15}O+p + p, since both ^{16}F and diproton systems are unbound. The low-energy spectrum of this nucleus consists of a series of resonances that are not yet well identified. In this work a

three-body model is used to describe the structure of ^{17}Ne, with special attention paid to the emergence of resonant states. Subsequently, the four-body Continuum-Discretizd Coupled-Channels (CDCC) is used to study the reaction of ^{17}Ne on a lead target at an energy around the Coulomb barrier. The comparison between the calculated elastic and breakup cross sections and the recent available experimental data (PLB 843 138007), provides an excellent framework for probing the resonant structure of this nucleus.

11:00-11:30 COFFEE BREAK

11:30-11:50 Alejandro Casado Galán: *Detection of Electromagnetic Side Channel Attacks on FPGA-based cryptohardware*

Abstract: Side Channel Attacks (SCAs) are a major concern in the current Internet of Things (IoT) paradigm. With its billions of devices, security in cryptohardware is essential to ensure confidential, authenticated and available data. Current cryptographic algorithms are theoretically secure, almost impossible to break. However, when implemented in silicon or other physical devices, vulnerabilities arise that can be exploited with SCAs. These attacks work by measuring some physical observable of the device with the aim of extracting the secret data that is processing inside (like the key of a cryptographic algorithm, for example). Electromagnetic (EM) SCAs aim to measure the EM radiation of an integrated circuit to infer the secret information that is processing inside. This type of attack is particurally dangerous because it does not require any tampering of the physical device, thus being very difficult to detect. In this work, I present a method of detection of EM probes (tools typically used to measure EM waves for SCAs) by using an Analog-to-Digital Converter (ADC) and very simple antennas mounted on an FPGA. The AES ecnryption algorithm was running on the device and results show that the countermeasure is able to detect probes before they can measure EM waves.

11:50-12:10 Joaquín Ceballos Cáceres: *Rad-hard electronics in extended temperature range for the Mars 2020 Mission*

Abstract: The space environment is hostile to CMOS electronic devices and commercial technologies for fabricating integrated circuits are not suitable for space applications. In the ASIC incorporated into the wind sensor of the Mars 2020 Mission, CMOS standard technology has been used with design modifications to make it resistant to radiation. Furthermore, the temperature range specified by the mission exceeds that specified by the suppliers of simulation models for their models. This talk will analyse the challenges posed by sending an ASIC to Mars, and how the designers overcame these challenges without resorting to space-specific technologies.

12:10-12:30 Bruno Fernández Sánchez-Hermosilla: *An Improved RTN-Based True Random Number Generation Technique Employing XOR Whitening*

Abstract: True Random Number Generators (TRNGs) are a fundamental building block in hardware security, providing the unpredictability required for cryptographic key generation and secure communications. This presentation explores the use of Random Telegraph Noise (RTN) as an entropy source for TRNGs, leveraging its inherent resistance to

aging-related degradation. While RTN-based generation through the Digital Maximum Current Fluctuation (DMCF) technique offers promising properties, its practical deployment is hindered by a critical sensitivity to the sampling time choice, which must be precisely tuned to device-specific defect dynamics, a constraint that is both technically demanding and difficult to generalize across fabrication process variations. The talk discusses how XOR Whitening, applied as a post-processing stage over multiple independent RTN-based bitstreams, effectively relaxes this tuning requirement while simultaneously improving randomness quality. Results validated with the NIST SP 800-22 test suite show NIST-compliant outputs over a substantially wider parameter range, with bit-rate scaling linearly with the number of devices. The presentation addresses the trade-offs this approach introduces in terms of area and power, and outlines the remaining challenges for its integration into real hardware security systems.

12:30-12:50 Yanjin Lyu: *A Synthesis Methodology for Band-Pass $\Delta\Sigma$ Modulators Based on N-Path Filters*

Abstract: This work presents a novel systematic methodology for the synthesis of the Loop Filters (LFs) in Band-Pass (BP) Delta-Sigma Modulators (DSMs) based on N-Path Filters (NPFs). Based on a linear time-domain transformation, the proposed method transform the problem of synthesizing the LFs of BP DSMs into a problem of synthesizing the LFs of conventional Continuous-Time (CT) Low-Pass (LP) DSMs. In this way, the complicated mixing effect caused by the linear periodically time-varying nature of NPFs in the frequency domain is avoided, thus resulting in a more efficient and simple synthesis method as compared to prior art. Moreover, well-known LF synthesis techniques for CT DSMs can be adopted, thus taking advantage of the know-how of conventional CT DSMs. A two-stage NPF-based BP DSM is synthesized using the proposed methodology, demonstrating correct simulation results as predicted by the presented theory.

12:50-13:10 Joseba Martínez Arrizabalaga: *Biometric Authentication for a High Level of Assurance in the European Digital Identity Wallet.*

Abstract: The European Digital Identity (EUDI) Wallet is a secure and user-controlled digital environment that will allow users to manage their personal identification data and attestation attributes to public and private services in the EU. The Wallet contains a Wallet Secure Cryptographic Device (WSCD) storing and managing the user's sensitive data, which communicates securely with the Wallet Instance (WI) at the user's device (typically a smartphone). For a widespread use of the EUDI Wallet, we propose a remote biometric authentication, so that the security does not depend on the quality of the user device. Biometric data cannot be used as a cryptographic key due to its variation between consecutive captures. Additionally, biometric data is considered personal sensitive information that needs to be protected. We implement a Fuzzy Extractor technique which allows to cope with the biometric data variability, protects it, and enables the extraction and recovery of cryptographic keys that are used for authentication.

13:10-13:30 Stamatis Argyroudis: *Design and Mechanical Validation of Microneedle Architectures for Wearable Biochemical Monitoring*

Abstract: Traditional clinical diagnostics rely on hypodermic needles, which cause pain and restrict data collection to intermittent snapshots, missing critical, real-time biochemical trends. While commercial wearables continuously track physiological markers, in situ biochemical sensing remains a formidable challenge. Microneedle technologies address the physical access gap by establishing a novel biointerface to sample interstitial fluid (ISF), aiming to transduce chemical concentrations into electrical signals. Realizing this shift toward preventive monitoring requires precise structural design to ensure efficient skin penetration. Here, we showcase a design-to-validation pipeline for next-generation microneedle arrays. CAD was used to engineer modular architectures with designs resembling bullets, arrows, pagodas, and pyramids. COMSOL Multiphysics FEA simulations predicted cutaneous tissue penetration to optimize these geometries, mitigate buckling, and evaluate user pain profiles. Optimized designs were fabricated via masked stereolithography 3D printing. Performance was verified through piercing tests on Parafilm M® and ex vivo porcine skin, successfully correlating experimental forces with FEA models. Mechanical resilience was confirmed via optical microscopy and axial fracture testing. This pipeline enables rapid geometry personalization for heterogeneous skin, offering a robust structural blueprint for future integrated electrochemical sensing systems.

13:30-13:50 Shangyu Wang: *PRED: Probabilistic Routing Expert Diffusion for High-Level Design of Sigma-Delta Modulators*

Abstract: This talk will present PRED, a probabilistic routing expert diffusion framework for the automated high-level design of Sigma-Delta modulators. The design of Sigma-Delta modulators involves an inverse mapping from target specifications, such as SNR, OSR, and power budget, to suitable circuit architectures and design variables. This mapping is inherently one-to-many and topology-dependent, making deterministic point-estimate regression insufficient in ambiguous or high-dimensional design spaces. PRED addresses this problem by combining an XGBoost-based probabilistic topology router with topology-dedicated conditional diffusion experts. The router retains plausible topology hypotheses, while the diffusion experts generate diverse candidate design vectors in each topology-specific parameter space. The generated candidates are evaluated using the SIMSIDES behavioral simulator and reranked according to Schreier's figure of merit. Experimental results on three switched-capacitor Sigma-Delta modulator topologies show that PRED improves both normalized FOM deviation and target-attainment rate over an ANN point-estimate baseline under the same best-of-10 simulation budget.

13:50-14:10 Yaohui Lu: *Physics-Informed Chain-of-Thought Fine-Tuning of Large Language Models for Explainable High-Level Design of Sigma-Delta Modulators*

Abstract: This paper proposes a high-level design method for Sigma-Delta modulators (SDM) based on fine-tuning large language models (LLMs) with physics-informed chain-of-thought (PI-CoT). First, high-quality training samples are extracted from raw simulation data through physical feasibility filtering and design space deconfliction based on Schreier figure of merit (FOM). Second, the XGBoost-based architecture prediction confidence combined with SHapley Additive exPlanations (SHAP) attribution analysis is used to construct architecture confirmation inference texts. Subsequently, a three-step physical causal chain is integrated to build the PI-CoT dataset covering four typical

SDM architectures. Furthermore, a SDM-domain LLM based on the PI-CoT dataset is fine-tuned. Behavioral-level simulation verification across four architectural test samples demonstrates that the proposed method achieves an average FOM satisfaction rate of 78.75%, exhibiting a significant advantage over general-purpose LLMs and machine learning methods. In addition, the generated design parameters possess genuine physical significance and exhibit strong interpretability.

Flash talks

14:10-14:15 Daniel Téllez Calle: *Breakdown Of Hydrodynamics In A Quasi-Two-Dimensional System*

Abstract: We derive an effective Navier-Stokes hydrodynamic description for a dilute gas of hard spheres confined between two parallel plates separated by a distance comparable to the particle diameter. For separations under two diameters, the system is quasi-two-dimensional, preventing particle pass-over. Applying a Chapman-Enskog expansion to a height-averaged Boltzmann equation derived from the BBGKY hierarchy (Physical Review E 110, 034127, 2024) yields transport coefficients as functions of microscopic parameters. As the plate separation approaches zero, the bulk viscosity diverges. This divergence stems from predominant head-on collisions inhibiting kinetic energy transfer between horizontal and vertical degrees of freedom, causing the per-axis energy anisotropy mode to slow to hydrodynamic timescales. Introducing an additional temperature anisotropy field regularizes this divergence, recovering the strict two-dimensional hard-disk limit under specified conditions. Molecular dynamics simulations of sound propagation validate these predictions, demonstrating how confinement-induced transport behavior manifests through the sound damping coefficient.

14:15-14:20 Juan Manuel Moreno Cenizo: *Efficient masked implementations of cryptographic primitives for PQC in IoT devices.*

Abstract:The Keccak core is a fundamental cryptographic primitive widely used in post-quantum cryptography to ensure security against emerging quantum-computing attacks. Secure software implementations rely on masking schemes to mitigate side-channel leakage, but these protections introduce significant overhead, which is particularly impactful on resource-constrained microcontrollers and further exacerbated by micro-architectural leakages. To date, publicly available masked Keccak implementations do not achieve both efficiency and robustness against such leakages. This work presents an optimized software implementation providing 1st-order side-channel protection, as well as the first efficiency-oriented 2nd-order implementation, surpassing previous solutions in performance. Both implementations target the ARM Cortex-M4 microcontroller and satisfy constraints to prevent micro-architectural leakages. A public repository provides the source code and a labeled dataset of 500K+500K traces, enabling reproducibility. Benchmarks show a 44.1% improvement over previously reported first-order implementations.

14:20-14:25 Yassine Lamouaraa Sedlackova: *Reducing Power Consumption in a Auto-Exposure Pixel Through Architectural Optimization*

Abstract: This presentation examines low-power architectural alternatives for a previously proposed auto-exposure pixel design. We identify the unwanted power consumption associated with inverter-based switching elements as a primary limitation of the current architecture and discuss several approaches to mitigate its impact. The benefits, trade-offs, and remaining challenges of these solutions are analyzed, providing a roadmap for future low-power sensor implementations.

Attendees (without talk):

- Gabriel Auñón Fernández
- Kashif Buland
- Guillermo Cortés Guillén
- Antonio de la Calle Martos
- Pablo Fernández Péramo
- Claudia Franco Moreno
- Miguel Galocha Oliva
- Daniel Jiménez Flores
- Daniel López Aires
- Carlos López Jiménez
- Manuel Mayo León
- Sebastian Matuszak
- Kiera Anne Mckay
- Juan Núñez Valdés
- Julia Pérez González
- Mario Pliego Padilla
- Fernando Puentes del Pozo
- Francisco Javier Reina Campo
- Mateo Ruiz Martín
- Antonio de la Misericordia Sojo López
- Félix David Suárez Bonilla
- Sergio Tejeda Campos
- Carmen Torres Muñoz
- Joel François Tsoplefack
- Alejandro Vegas Díaz