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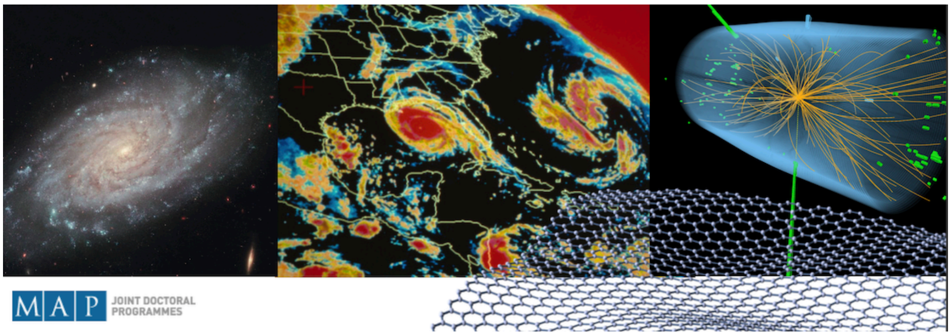

Book of Abstracts

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Ionospheric response to geomagnetic storms of different intensity in the Eastern North Atlantic mid-latitudinal zone: comparison between Lisbon, Azores and Madeira

Authors: Anna Morozova[1]; JOÃO LIMA[None]; Shedrach Chiaha[2]; Teresa Barata[1]

[1] *University of Coimbra*

[2] *University of Porto*

Corresponding Authors: mtbarata@gmail.com, up202308817@up.pt, annamorozovauc@gmail.com, jlima@astro.up.pt

Geomagnetic storms during the declining phase of the solar cycle 24 were studied using the total electron content (TEC) data obtained from three geodetic receivers located in Portugal: Lisbon (Continental Portugal), Furnas (Azores) and Funchal (Madeira). Two of the receivers (Lisbon and Furnas) are located at about the same latitude (˜39ºN) while the third receiver (Funchal, ˜33ºN) is positioned quite well to the south.

In this work, we study TEC variations during geomagnetic storms (Dst <= -50 nT) observed between 2015 and 2019. We draw conclusions on the strength and the type of the ionospheric response, and on geomagnetic and other conditions that favour a significant ionospheric storm in the studied region. Special attention is given to the analysis of the longitudinal and latitudinal (dis)similarities in the ionospheric variations observed at three studied locations.

Which topic best fits your talk?:

Climate and Environment

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Accretion of Generalized Chaplygin Gas onto Black Holes in an Expanding Universe

Author: Luís Reis[1]

Co-authors: Mário Baldiotti [2]; Orfeu Bertolami [1]

[1] *University of Porto*

[2] *State University of Londrina*

Corresponding Author: up202209156@edu.fc.up.pt

The study of the Generalized Chaplygin Gas (GCG) has established itself in recent years as an active and highly relevant field of research in cosmology. The GCG features an exotic equation of state that not only provides an effective description of the late-time accelerated expansion of the universe but also allows for the construction of a unified model of dark energy and dark matter. As a way to investigate local aspects of the model and to propose a novel method for constraining its fundamental parameters, we examine the accretion of this fluid by black holes. To incorporate the global features of the GCG into this analysis, we employ the so-called McVittie metric. In this framework, accretion is studied while accounting for the backreaction on the elements of the metric. Through a perturbative approach, we derive an expression for the black hole mass as a result of accretion. For clarity, this analysis is carried out in two distinct cosmic eras: first, in a matter-dominated era; and later, in a dark-energy-dominated era.

Which topic best fits your talk?:

High Energy Physics and Cosmology

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Harnessing Light for Computing: Neuromorphic Architectures and Analogue Photonic Platforms

Author: Vicente Rocha[None]

Corresponding Author: vicentevrocha.vvr@gmail.com

Optical computing has long been regarded as a promising avenue for fast and energy-efficient information processing. The field has already made significant contributions to modern technology by enhancing performance in specialized tasks such as matrix-matrix multiplication, Fourier transforms, and convolutions. Despite these successes, the development of an optical algorithm capable of addressing a broader range of problems remains a challenge, motivating the search for alternative computation frameworks that exploit the unique advantages of light. A promising pathway lies in the development of photonic neuromorphic devices. By encoding memory through the linear weights of the network and exploiting the universal function approximation capabilities of neural networks, this approach offers a versatile and scalable framework for analog optical computing.

In this direction, we investigate Photonic Extreme Learning Machines (PELMs), a class of architectures inspired by the Extreme Learning Machine (ELM) algorithm. According to the ELM theory, the random initialization of hidden-layer weights and biases, together with nonlinear and non-polynomial activation functions, is sufficient to guarantee universal function approximation. In the optical domain, the bypass of weight training results in improved energy-efficiency and robustness to noise. This paradigm has been implemented in diverse configurations, ranging from free-space propagation to tunable integrated optics. However, a comprehensive theoretical model capable of describing these systems and capabilities remains absent. In our work, we develop such a model and establish its correspondence with ELM theory, enabling the identification of the computational role of individual optical components and highlighting current limitations and opportunities for future development.

Another front of our research addresses the weak nonlinearities of optical systems. To this end, we investigate the dynamics of light in nonlinear media, where self and cross-interaction between beams give rise to rich nonlinear behaviour. In particular, we focus on Fluids of Light, a paraxial propagation regime that exhibits close analogies with quantum fluids. From superfluidity to turbulence and the Kolmogorov energy cascade, as well as vortex generation, these systems host exotic phenomena with largely unexplored potential for computation. Our work explores how geometrical properties of refractive-index landscapes can be engineered to control the input–output response of light. Currently, we are validating our experimental platform by reproducing reported results on light localization in photonic Moiré lattices. In contrast with other optical configurations, our approach leverages Spatial Light Modulators (SLMs) to independently modulate the amplitude and phase (velocity) of input states of light, thereby providing an additional level of tunability and versatility.

Which topic best fits your talk?:

Optics and Photonics

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Interplay between astrophysics and cosmology at LISA

Authors: Germano Nardini[1]; Marco Finetti[2]; Nikolaos Karnesis[None]

[1] *University of Stavanger*

[2] *Aveiro University*

Corresponding Authors: karnesis@auth.gr, mfinetti@ua.pt, germano.nardini@uis.no

We examine how a cosmological stochastic gravitational-wave background could interfere with the standard procedure used in LISA data analysis to subtract bright, individually detectable Galactic binaries. This subtraction step is essential for revealing weaker, unresolved signals, but the presence of an additional cosmological background can distort the outcome. We quantify this effect by studying how it influences the ability to reconstruct the parameters of the cosmological background itself.

Which topic best fits your talk?:

High Energy Physics and Cosmology

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Analytical results for the quantum dynamics of electrons under strong fields with dissipation

Author: João Manuel Alendouro Oliveira Pinho[1]

Co-authors: Bruno Amorim [1]; João Viana Lopes [1]

[1] *Centro de Física do Porto*

Corresponding Authors: jlopes@fc.up.pt, up201703751@edu.fc.up.pt, bamorim@fc.up.pt

The theory of open quantum systems is one of the most essential tools for the development of quantum technologies. A particular area of interest is in the optical response of solid state systems, where dissipation is introduced phenomenologically through the relaxation time approximation and its effects are usually gauged perturbatively . Here, we obtain the analytical solution for a general single-band tight binding system under the influence of a generic uniform, time-dependent electric field under the relaxation time approximation. We explore the effects of dissipation in two limiting cases: A monochromatic field, where we analytically deduce the effect of dissipation on High Harmonic Generation, and a constant electric field, where a generalization for the Esaki-Tsu equation is presented for any single-band tight-binding system. We apply the results to a two-dimensional tilted square lattice with nearest-neighbours. The validity of perturbation theory results for vanishing dissipation is also analyzed against our exact result. We conclude that divergences present in first order current response are purely artifacts of perturbation theory and do not reflect physical behaviour.

Which topic best fits your talk?:

Condensed Matter Physics and Nanomaterials

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Future climate wildfire modelling using the atmosphere-fire coupled model WRF-SFIRE, under different landscape management scenarios

Author: Ricardo Vaz[None]

Co-authors: David Carvalho ; Paula Maia [1]; Susana Carsoso Pereira [2]

[1] *Department of Biology , Centre for Environment and Marine Studies (CESAM), University of Aveiro*

[2] *Department of Physics, Centre for Environment and Marine Studies (CESAM), University of Aveiro*

Corresponding Authors: david.carvalho@ua.pt, paula.maia@ua.pt, ricardojorgevaz@ua.pt, susana.cardoso@live.ua.pt

In recent decades, Portugal has been increasingly impacted by large wildfires, responsible for socio-economic and ecological damages. This work aims to develop a framework to improve landscape resilience wildfire under a changing climate, the WRF-SFIRE coupled atmosphere-wildfire modelling system was employed. "Landcover data were mapped to NFFL fuel models using bioclimatic analysis, producing alternative landcover maps representing future climate conditions. High fire risk events obtained from future climate simulations were selected as a means of testing different assigned landcovers. The lack of potentially usable NFFL fuel models provided an opportunity to assess their performance by comparing them to the national Portuguese fuel models, created by landcover analysis within Portugal. In addition to diversifying the fuel model base information, the impact of the atmosphere-fire feedback via heat and mass flows from the surface burning in the atmosphere on fire spread and fire intensity was analyzed. Four medium sized wildfires (≤1000 ha) were selected from an historical wildfire database for testing, and four simulations were carried out per wildfire, with atmosphere-fire feedback on and off for the NFFL fuel models and Portuguese fuel models. Simulations with atmospheric feedback enabled showed little differences in both burnt area and fire intensity for small to medium sized fires, with less burned area and intensity. Both fuel model systems showed disparities in the results greater than the disparities in the feedback simulations. For the NFFL fuel models total burned area was always overestimated whereas the Portuguese fuel models overestimated three and underestimated one wildfire burned area. Potential applicability of Portuguese fuel models has shown greater realism in comparison with the NFFL, underscoring the need to perform additional validation for larger wildfires, in which atmospheric feedback mechanisms are expected to be more emphasized.

Which topic best fits your talk?:

Climate and Environment

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The heavy spectrum of holographic CFTs

Authors: Filipe Miguel Martins Macedo Serrano Coelho[None]; Miguel Correia[1]; Vasco Gonçalves[2]

[1] *EPFL - Ecole Polytechnique Federale Lausanne (CH)*

[2] *Porto University*

Corresponding Authors: miguel.alexandre.ribeiro.correia@cern.ch, vasco.dfg@gmail.com, up202213096@edu.fc.up.pt

A holographic Conformal Field Theory (CFT) is characterized by a sparse spectrum with a large gap, that ensures that no higher spin field exist at low energies, and a large central charge, which implies a Fock space structure in the spectrum of local operators. But these scales are also related to interesting physics, namely extended objects in the gravitational theory. Using the effective field theory framework for extended objects, we can describe heavy physics in terms of observables that naturally appear in the conformal bootstrap program and identify the CFT data that codifies the geometric structure of an extended object in asymptotically Anti-de-Sitter.

Which topic best fits your talk?:

High Energy Physics and Cosmology

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Hybrid fiber sensors based on self-written polymer waveguide

Author: João Santos[1]

Co-authors: Jeroen Missinne [2]; Jörg Bierlich [3]; Marta Ferreira [1]

[1] *Universidade de Aveiro*

[2] *Ghent University*

[3] *Leibniz Institute of Photonic Technology*

Corresponding Authors: joerg.bierlich@leibniz-ipht.de, marta.ferreira@ua.pt, jpfsantos@ua.pt, jeroen.missinne@ugent.be

Silica based optical fibers composed of different commercial and specialty fibers spliced together for the measurement of physical parameters were developed. These structures were interfaced with self-written waveguides (SWWs) based on UV curable polymers, forming a thin Fabry-Perot (FP) polymer cavity in front of the fiber tip after UV exposure from the fiber structure itself. This method was developed and characterized in fibers composed of single mode, multimode, air capillaries, microstructured fibers, and a combination of the above. Both Norland Adhesives (NOAs) and OrmoCers were used as the polymers of choice for the self-growing photopolymerizing method. These structures were characterized to temperature and humidity, where the combination of the fiber FP interferometers (FPI) located in silica and/or air and the polymer FPI give rise to a hybrid sensing structure that can simultaneously detect two or more measurands. Additionally, a study of the annealing of the SWWs was carried out, which revealed a varying temperature sensitivity of the polymer based on the degree of curing it presented.

Which topic best fits your talk?:

Optics and Photonics

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III-V Semiconductor Nanopillar Arrays for an Insect Vision Inspired Neuromorphic On-Chip Platform

Author: João Azevedo[1]

[1] *INL - International Iberian Nanotechnology Laboratory*

Corresponding Author: id11142@alunos.uminho.pt

We present the building blocks of an energy-efficient on-chip platform for neural network applications based on III-V semiconductor nanopillar arrays. This approach draws inspiration from insect eyes and their neuronal architecture, as they allow for remarkable capabilities to extract and process information from the surrounding environment with extremely low energy consumption.

A bio-mimicking optimized visual perception mechanism is addressed by implementation of nanopillars in Gallium Arsenide (GaAs) for interpretation of incoming light-coded information. We aim the development of a network based on nanopillar device neurosynaptic nodes, as an energy-efficient on-chip nano-optoelectronic platform that will also include memory solutions. When integrated in CMOS technology, these structures can enable reliable approaches for light-driven neurorobotics, bio-inspired optoelectronics, and ultimately brain-machine interfaces.

The nanopillar arrays consist of an epilayer of GaAs and Aluminium Gallium Arsenide (AlGaAs) layer stacks with a double-barrier quantum well (DBQW) structure that defines its operation as a synaptic receptor with a negative differential conductance region. A light-emitting diode (LED) structure is also included for oscillatory spike signalling. Several lattice parameters (including pillar diameter and periodicity distance –*pitch*) were tested through FDTD simulations. The fabrication steps of nanopillar-based devices in cleanroom environment included e-beam lithography, dry-etching of the semiconductor material, chemical passivation and metallization of the electrical contacts. Tests were performed in elliptical pillars having semi-minor axis lengths as low as 150 nm, in compact layouts with pitch values down to only 2 times the semi-minor axis.

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Condensed Matter Physics and Nanomaterials

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Phase Transitions and Uniaxial Negative thermal Expansion in CsNdNb2O7: Combined Local Probe and Diffraction Study

Author: Pedro Alexandre Silva De Sousa[1]

Co-authors: Neenu Lekshmi [2]; António Cesário ; Pedro Rodrigues ; Helena Petrilli ; Lucy Assali ; Estelina Silva ; Samuel Santos ; Guilherme Correia ; João Pedro Araújo ; Armandina Lopes

[1] *Universidade do Porto (PT)*

[2] *IFIMUP*

Corresponding Author: up201704307@edu.fc.up.pt

Zhu et al. [1] report that the $CsNdNb_2O_7$ system undergoes two phase transitions: a polar-to-antipolar structural change at 625 K followed by a transition to the aristotype at 800 K, resulting in three distinct phases—P21am (#26), C2/m (#12), and P4/mmm (#123). Their study attributes these transitions to rotations and tilts of NbO_6 octahedra, which not only stabilize the polar ferroelectric phase but also induce negative thermal expansion (NTE) in the c-axis lattice parameter during the 625 K transition.

Building on these findings, our work employs a multimodal strategy to systematically investigate the phase behavior and structural evolution of $CsNdNb_2O_7$. Synchrotron X-ray diffraction (SXRD) provides high-precision measurements of lattice parameters and confirms the occurrence of NTE [1]. However, due to SXRD's limited sensitivity to light elements and subtle local distortions, we incorporate three complementary techniques:

- Perturbed Angular Correlation (PAC) Spectroscopy: A local probe is highly sensitive to atomic-scale dynamics, measuring the electric field gradient (EFG) at specific sites to capture information on local symmetry and NbO_6 rotational environments.
- Neutron Powder Diffraction (NPD): Leveraging the large neutron scattering cross-section of oxygen, NPD accurately determines oxygen positions, enabling detailed quantification of temperature-dependent distortions in both the perovskite and rock-salt layers, which are directly linked to the NTE mechanism.
- Density Functional Theory (DFT): Utilizing structural data from NPD, DFT calculations provide theoretical EFG values and offer an in-depth analysis of the electronic and structural intricacies underlying the phase transitions.

By integrating local (PAC), long-range and oxygen-sensitive (NPD), and theoretical (DFT) methodologies, our approach delivers critical new insights into the underlying mechanism of negative thermal expansion (NTE).

Our findings not only confirm the previously proposed structural evolution in $CsNdNb_2O_7$ but also underscore the importance of a multimodal characterization strategy in understanding phase transitions and thermal expansion anomalies in layered perovskites, particularly within the Dion-Jacobson family.

[1] Zhu T., et al., Chemistry of Materials 32, 10, 4340–4346 (2020).

Which topic best fits your talk?:

Condensed Matter Physics and Nanomaterials

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Dopant-vacancy synergy effects on ferroelectric La:ZrO2

Author: Alexandre Silva[1]

Co-authors: Luis Marques [1]; Veniero Lenzi [1]

[1] *Universidade do Minho*

Corresponding Authors: veniero.lenzi@fisica.uminho.pt, alexandre.silva@fisica.uminho.pt, lsam@fisica.uminho.pt

Ferroelectric (FE) zirconium oxide ($ZrO2$) thin films are a promising alternative to hafnium oxide ($HfO2$) for low-power, high-speed memory devices due to their greater natural abundance and lower crystallization temperature. Ferroelectricity arises from the metastable polar orthorhombic (o-, s.g. Pca21) phase, making its stabilization central to obtaining functional FE properties.

Heterovalent doping with trivalent cations, such as Lanthanum, has been shown, both experimentally and theoretically, to promote the o-phase stability and enhance FE properties. However, this type of doping creates a charge imbalance that in FE ZrO2 films is typically compensated ionically, i.e. by the formation of charged oxygen vacancies (VO2+) that, in turn, affect the phase stability and FE properties. The effects of dopants and vacancies have been studied individually, but how their combined presence influences the properties of FE ZrO2 films is not yet clear.

In this work, we employ density functional theory (DFT) calculations to investigate how configurational disorder and charge compensation influence the FE properties and switching of o phase La:ZrO2. We find an intrinsic preference for ionic compensation via spontaneous VO2+ formation. Both the compensation mechanism and dopant spatial configuration strongly influence the spontaneous polarization and piezoelectric response. Moreover, the La distribution determines the favorable VO formation sites, driving the formation of La–VO–La complexes. These complexes introduce asymmetries in polar state energies and switching energy barriers, suggesting a possible microscopic origin for the pinning of ferroelectric domains.

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Condensed Matter Physics and Nanomaterials

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Machine learning anomaly detection techniques at LHC with ATLAS experiment

Authors: Annalisa Berti[1]; Nuno Castro[2]; Rute Pedro[1]

[1] *Laboratory of Instrumentation and Experimental Particle Physics (PT)*

[2] *LIP and University of Minho*

Corresponding Authors: nuno.castro@cern.ch, rute.pedro@cern.ch, annalisa@lip.pt

In this work is treated the employment of Machine Learning techniques as statistical data analysis tool in the research field of high energy physics.
The quantum field theory of Standard Model remains, today, the most faithful description of the fundamental behavior of nature: most of the predictions about the fundamental matter composition and its interaction laws have found experimental confirmation in particle accelerators and cosmic rays detectors.
The Standard Model is not perfect though: it presents many shortcomings both from the theoretical and experimental point of view.
In this research, Machine Learning will be employed to enlarge the sensitivity of a data analysis procedure lead with the ATLAS experiment collaboration at LHC (Large Hadron Collider), the particle accelerator of CERN.
The analysis in question is the search for invisible particles produced in association with boosted bosons in proton–proton collisions at a center of mass energy of 13 TeV at the LHC; unsupervised Machine Learning models are implemented to find parameter regions for which the presence of a "new physics" signal is enhanced with respect to the background composed by other Standard Model

predicted expected processes taking place. The unsupervised nature of the discriminating model offers the possibility of not focusing the search on a specific process belonging to a specific theoretical model of new physics.
Secondly, in this research is treated the application of Machine Learning to another step of the analysis: the assessment of the detector status. The same techniques used in the just mentioned physical analysis, are used to automatize the spotting of malfunctioning channels during the data quality check procedure in the Tile Hadronic Calorimeter: one of the ATLAS sub-detectors.

Which topic best fits your talk?:

High Energy Physics and Cosmology

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Using Machine Learning to Scan Beyond Standard Model Parameter Spaces

Author: Fernando Souza[None]

Corresponding Author: abreurochasouza@gmail.com

In High Energy Physics, when testing theoretical models of new physics against experimental results, the customary approach is to simply sample random points from the parameter space of the model, calculate their predicted values for the desired observables and compare them to experimental data. However, due to the typically large number of parameters in these models, this process is highly time consuming
and inefficient. We propose a solution to this by adopting optimization algorithms which make use of Machine Learning methods in order to improve the efficiency of this validation task.
A first study applied these methods to conventional Supersymmetry realisations, cMSSM and pMSSM, when confronted against Higgs mass and Dark Matter relic density constraints and the results show an increase in up to 3 orders of magnitude in sampling efficiency when compared to random sampling. In a much more challenging scenario, a followup analysis was implemented for the scotogenic model, using an evolutionary multiobjective optimization algorithm, confronted against experimental constraints coming from the Higgs and neutrinos masses, lepton flavor violating decays, neutrino mixing and the anomalous magnetic moment of the muon. Results show that these algorithms are more efficient, converge faster and more importantly are able to find new viable regions of the parameter space and new phenomenology when compared to the typical Markov Chain Monte Carlo. We present new dark matter phenomenology for the scotogenic model where we show for the first time in similar studies viable Fermionic dark matter with cross section below the LUX-ZEPLIN upper bound and above the neutrino floor.

Which topic best fits your talk?:

High Energy Physics and Cosmology

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How surface charge controls the onset temperature of LDL fluctuations in ambient liquid water

Author: Ramon Raposo Filho[1]

[1] *University of Aveiro*

Corresponding Author: rraposofilho@ua.pt

Several studies have now shown that the polymorphism of water also extends to ambient conditions, the stability and size of the liquid tetrahedrally domains (LDL) decrease upon heating, with significant implications for biological function and nanotechnology [1,2].

In our new work, we demonstrate that the onset temperature of LDL domain fluctuations in ambient liquid water at the surface of nanoparticles is highly sensitive to its surface charge density, providing a unifying framework to understand hydration water behavior in complex systems.
By combining temperature-dependent Brownian dynamics and zeta potential measurements on lanthanide-doped upconversion nanoparticles (UCNPs) with varied surface functionalizations, we establish a master curve relating crossover temperature to effective surface charge.

Our results reveal that increasing surface charge elevates the LDL onset temperature, converging toward the bulk water value (~330K). This trend highlights how interfacial electrostatics modulate water structuring, offering predictive control of hydration water dynamics.

Together with recent reports of other water-suspended materials, such as QDs, plasmonic NPs, Ag2S NPs, organic molecules, and aqueous complexes. These findings will lead us to a fundamental understanding of the role played by water in the thermal stability of biomolecules and dielectric behavior in confined systems. Opening pathways for nanofluid engineering in biomedicine and energy systems.

[1] F. Maturi, R. S. Raposo Filho, C. D. S. Brites, J. Fan, R. He, B. Zhuang, X. Liu, L. D. Carlos, J. Phys. Chem. Lett. 2024, 15, 2606–2615.
[2] R. S. Raposo Filho, C. D. S. Brites, J. Fan, R. He, B. Zhuang, X. Liu, L. D. Carlos, Physics of Fluids, 2025, 37.2.

Which topic best fits your talk?:

Optics and Photonics

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Fano resonances between the emission of J-aggregate-covered metallic nanorods and spherical cavity modes

Author: Diogo Cunha[1]

Co-author: Mikhail Vasilevskiy

[1] *University of Minho*

Corresponding Authors: id10651@alunos.uminho.pt, mikhail@fisica.uminho.pt

We investigate, both experimentally and theoretically, photoluminescence (PL) spectra of J-aggregates (JC1) covering silver nanorods (AgNRs). When these hybrid nanoparticles (J-agg@AgNRs) are deposited on the surface of a spherical microcavity (MC), their non-resonantly excited PL spectra show a series of sharp resonances in the broad spectral range of 550 – 650 nm, characterized by Fano-type lineshapes.
We develop a semi-phenomenological model based on coupled-oscillator equations, which explains the observed spectra of the J-agg@AgNRs/MC system. In particular, it is shown that the complex Fano-type lineshapes are due to effective interaction of various whispering gallery modes of the microsphere, coupled to the J-agg@AgNR emitter. Our experimental results and their understanding qualify the investigated hybrid structure as a sensitive and controllable system, suitable for applications.

Which topic best fits your talk?:

Condensed Matter Physics and Nanomaterials

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Impacto das alterações climáticas na formação de Cold Air Pooling (CAP) na Região Demarcada do Douro

Author: Marta Teixeira[None]

Co-authors: António Graça ; David Carvalho ; João Santos

Corresponding Authors: david.carvalho@ua.pt, antonio.graca@sogrape.pt, martasteixeira@ua.pt, jsantos@utad.pt

A interação entre clima e meteorologia influencia profundamente diversos setores, em particular a agricultura, sendo a viticultura um exemplo de destaque em Portugal. Apesar da sua dimensão relativamente pequena, o país possui numerosas regiões vitivinícolas, cada uma com características próprias de clima, solo, castas e tradições. As alterações climáticas e as condições meteorológicas impactam significativamente a produção de vinho, provocando quebras de produção e perdas de qualidade durante eventos meteorológicos extremos. A Região Demarcada do Douro (RDD), reconhecida pela sua topografia exigente, continua a produzir uma quantidade significativa de vinhos, incluindo variedades de renome, reconhecidas internacionalmente pela sua excecional qualidade. Contudo, a região enfrenta desafios, entre os quais a formação de fenómenos meteorológicos específicos, como as *cold air pooling* (CAPs), que ainda não foram devidamente estudadas na RDD. Este estudo tem como objetivo investigar a ocorrência e o impacto futuro das CAPs na RDD, recorrendo às projeções do CMIP6. Dados históricos da SOGRAPE Vinhos SA complementarão a investigação, fornecendo informações valiosas sobre as condições nas vinhas. O estudo envolverá a identificação das CAPs, a avaliação do seu impacto nas vinhas e a análise das implicações futuras das CAPs na produção de vinho através de técnicas de downscaling de alta resolução. Os resultados contribuirão para uma melhor compreensão da relação entre as CAPs e a produção de vinho na RDD, apoiando o desenvolvimento de estratégias de adaptação para o futuro.

Which topic best fits your talk?:

Climate and Environment

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AdS x S Mellin Bootstrap and Hidden Symmetry of Five-Point Functions in N=4 SYM

Author: Carlos Bruno Dias Fernandes[None]

Co-authors: Ellis Ye Yuan ; João Vilas Boas ; Vasco Gonçalves ; Yichao Tang ; Zhongjie Huang

Corresponding Author: up201706002@edu.fc.up.pt

We propose an AdS$\times$S factorization formula at the level of the generating function for correlators with arbitrary Kaluza-Klein configurations, and implement it in the supergravity limit of $\mathcal{N} = 4$ super Yang-Mills. By incorporating this mechanism into Mellin space bootstrap, together with an observed $\mathbb{Z}_2$ symmetry under AdS $\leftrightarrow$ S, we manage to simultaneously work out unified formulas both for all five-point half-BPS correlators and for all four-point correlators with one superdescendant. This AdS$\times$S bootstrap method is directly applicable to generic multi-point computation at tree level.

Which topic best fits your talk?:

High Energy Physics and Cosmology

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Fiber-Integrated 3D Nanoprinted Antiresonant Hollow-Core Waveguide for Optofluidics Applications

Author: Diana Pereira[1]

Co-authors: Markus A. Schmidt [2]; Marta S. Ferreira [3]

[1] *i3N - Universidade de Aveiro & Leibniz Institute of Photonic Technology - Germany*

[2] *Leibniz Institute of Photonic Technology - Germany*

[3] *i3N & Departamento de Fisica - Universidade de Aveiro*

Corresponding Authors: dsap@ua.pt, marta.ferreira@ua.pt, markus.schmidt@leibniz-ipht.de

Guiding light in hollow core waveguides is a key direction in fiber optics, offering transformative applications. Yet, fabrication limits have prevented their full use in planar systems. Here, we introduce a fiber-integrated hollow-core waveguide that apply the antiresonant guiding principle to planar technology through 3D nanoprinting. High-aspect-ratio structures are printed directly on fiber end faces, enabling seamless integration, polarization-independent transmission, and reduced losses. Experiments, simulations, and models show strong agreement. We further demonstrate optofluidic applications, including precise refractive index sensing and absorption spectroscopy. This compact platform opens opportunities in biomedicine, quantum optics, and environmental monitoring.

Which topic best fits your talk?:

Optics and Photonics

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VIGILant: an automatic classification pipeline for glitches in the Virgo detector

Author: Tiago Fernandes[1]

Co-authors: Alejandro Torres-Forné [2]; Antonio Onofre [3]; Francesco Di Renzo [4]; José A. Font [2]

[1] *Centro de Física das Universidades do Minho e de Porto / Universitat de València*

[2] *Universitat de València*

[3] *Universidade do Minho/CFUMUP,LIP*

[4] *INFN / Universit ‘a di Firenze*

Corresponding Author: antonio.onofre@cern.ch

Gravitational wave data are often contaminated by transient noise artifacts, called “glitches”, which can mimic astrophysical signals and interfere with their detection. When represented in the time-frequency domain, glitches show peculiar morphologies, which allow their categorization into distinct families. As it is expected that glitches which share a similar morphology also share the same origin, this classification is very useful for detector characterization activities. Although this classification can be done manually by eye, Machine Learning methods have proved to be very powerful for these tasks. With this goal in mind, we present an automated classification pipeline for glitches from the Virgo gravitational wave detector, which classifies new glitches into the respective families and provides this information to the collaboration members. For each glitch, the pipeline takes as input the respective Omicron trigger. After the creation of the glitch spectrogram, it is fed to a Convolutional Neural Network, which was previously trained to achieve good classification accuracy. This neural network outputs the predicted glitch family. Then, these predictions are aggregated over a time period and plots which allow to study the population of glitches over that period and compare it with other periods. This automated pipeline provides timely feedback for detector characterization, supporting efforts to improve the detector and enhance gravitational wave detection.

Which topic best fits your talk?:

Astrophysics

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Inflationary dynamics of non-minimally coupled f(R) matter-curvature theories

Author: Miguel Barroso Varela[1]

Co-authors: Andreas Mantziris [2]; Orfeu Bertolami [2]

[1] *Centro de Física do Porto - University of Porto*

[2] *University of Porto*

Corresponding Authors: up201907272@edu.fc.up.pt, andreas.mantziris@fc.up.pt

This study examines how inflationary dynamics are affected by $f(R)$ theories with a non-minimal coupling between matter and curvature. Both positive and negative corrections to the minimal coupling of General Relativity are considered, and a robust numerical method is developed that evolves the metric and the inflaton field in this modified theory beyond slow-roll. Through a stability analysis, we find that positive models are inherently unstable during slow-roll, whereas negative ones can accommodate a stable attractor de Sitter solution. Using the amplitude of the scalar power spectrum from the latest data releases, we constrain the scale of the non-minimal coupling to be above 10^{13} GeV. In light of the 2018 Planck, BICEP/Keck and the recent Atacama Cosmology Telescope data for the scalar spectral index and tensor-to-scalar ratio, strong constraints on the coupling strength force the effects of these modified theories to be, at most, slightly above the perturbative level. Furthermore, we determine that the choice of the perfect fluid matter Lagrangian does not impact the inflationary observables at the pivot scale. Finally, we present the predicted observables for different inflationary potentials and show that even though classical gravity is still preferred by the data, there are areas of the parameter space that are viable for non-minimally coupled inflationary models.

Which topic best fits your talk?:

High Energy Physics and Cosmology

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Instability of Q-Hairy Black Holes

Author: José Ferreira[1]

[1] *University of Aveiro*

Corresponding Author: jpmferreira@ua.pt

GW observations in the last decade have reinforced the Kerr BH paradigm, but these conclusions rely on waveform catalogs dominated by Kerr BH. Expanding the diversity of modeled sources is essential to uncover potential new physics. However, only bodies whose stability is known can become viable alternatives. Here, we study the stability of Q-hairy BHs, solutions in the Einstein-Maxwell-Scalar model that evade well-known uniqueness theorems.

Which topic best fits your talk?:

Astrophysics

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Bulk Impurities/Vacancies in Nodal Loop Semimetals

Authors: João Santos Silva[1]; Eduardo Castro[2]; Miguel Araújo[3]

[1] *CF-UM-UP, Centro de Física do Porto, FCUP*

[2] *CF-UM-UP*

[3] *Universidade de Évora*

Corresponding Author: jss.joaossilva@gmail.com

Weyl nodal loop semimetals are topological semimetals where the valence and conduction bands linearly touch along one dimensional loops in momentum space. A manifestation of their non-trivial topology is the presence of zero energy surface states, induced by chiral symmetry, on surfaces parallel to the loop plane. Unlike their insulator counterparts, these exotic phases may be unstable to small perturbations that respect their topology-protecting symmetries. Results for symmetry-breaking disorder have been reported (M. Gonçalves, P. Ribeiro, E. V. Castro, and M. A. N. Araújo, Phys. Rev. Lett. 124, 136405 (2020)). However, vacancies preserve chiral symmetry, and remain a largely open problem.
Here, we will discuss the effects of impurities and vacancies in the bulk of a Weyl nodal loop semimetal (M. Gonçalves, P. Ribeiro, E. V. Castro, and M. A. N. Araújo, Phys. Rev. Lett. 124, 136405 (2020)). In an effective low energy model for a nodal loop, an analytical approach is tractable. We focus on the changes in the density of states (DOS), computed via a projected Green's function formalism, and study the localization of the impurity-induced bound states. We have found that a single cell-impurity induces a peak in the DOS, which traverses zero energy as its strength increases, becoming sharper near the Fermi level, in line with known literature (Tao Zhou, Wei Chen, Yi Gao, and Z. D. Wang, Phys. Rev. B, 100:205119, Nov 2019). Contrary to Weyl point semimetals and graphene, our results are consistent with the existence of a finite critical impurity strength that lifts the DOS at zero energy. Moreover, the impurities create bound states, with tails decaying as r^{-4}.
A single cell-vacancy creates broad peaks on both sides of the Fermi level, while the system remains a semimetal. Orbital-vacancies induce a sharp peak at zero energy. Lastly, we also look at the linear optical response of the nodal loop semimetal in the presence of vacancies.

Which topic best fits your talk?:

Condensed Matter Physics and Nanomaterials

159

Invisible Higgs decay from dark matter freeze-in at stronger coupling

Author: Vinícius Oliveira[1]

[1] *Universidade de Aveiro*

Corresponding Author: viniciuslbo@ua.pt

We study the Higgs boson decay into dark matter (DM) in the framework of freeze-in at stronger coupling. Even though the Higgs-DM coupling is significant, up to order one, DM does not thermalize due to the Boltzmann suppression of its production at low temperatures. We find that this mechanism leads to observable Higgs decay into invisible final states with the branching fraction

of 10% and below, while producing the correct DM relic abundance. This applies to the DM masses down to the MeV scale, which requires a careful treatment of the hadronic production modes. For DM masses below the muon threshold, the Boltzmann suppression is not operative and the freeze-in nature of the production mechanism is instead guaranteed by the smallness of the electron Yukawa coupling. As a result, MeV DM with a significant coupling to the Higgs boson remains non-thermal as long as the reheating temperature does not exceed
O(100) MeV. Our findings indicate that there are good prospects for observing light non-thermal DM via invisible Higgs decay at the LHC and FCC.

Which topic best fits your talk?:

High Energy Physics and Cosmology

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Spatially and temporally modulated active patches for skin cancer treatment

Author: Diana Bogas[1]

[1] *Centro de Física das Universidades do Minho e do Porto*

Corresponding Author: id11141@alunos.uminho.pt

Skin cancer is the most common of all cancers and can be divided in three types: basal cell carcinoma, squamous cell carcinoma, and melanoma, the latter being the most aggressive. Current therapies for melanoma present several drawbacks, which highlights the need for new therapeutic approaches.
Electroactive, biocompatible, and biodegradable polymers, such as poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV) and silk fibroin (SF), are attracting increasing interest for the development of active scaffolds in tissue engineering applications.
In this study, films and fibers with different PHBV/SF ratios were produced by solvent casting and electrospinning, respectively. The materials were subjected to phycochemical and biological characterization. Their biological performance was evaluated using HaCat keratinocyte cells to mimic skin conditions. Additionally, the effect of an active microenvironment was investigated by applying mechanical stimulation to induce an electrical response through the piezoelectric polymers. The materials showed no cytotoxicity and promoted the proliferation of HaCat cells after 7 days of culture. Furthermore, mechanoelectrical stimulation appears to enhance keratinocyte proliferation, particularly in samples with higher SF content.
In conclusion, this study shows promising results for the development of active patches for skin cancer treatment.

Which topic best fits your talk?:

Biophysics and Biomaterials

169

Transport of aerosols by atmospheric rivers in the Iberian Peninsula

Author: Diogo Luís[1]

Co-authors: Irina Gorodetskaya [2]; Carla Gama [1]

[1] *CESAM, University of Aveiro*

[2] *CIIMAR, University of Porto*

Corresponding Author: diogo.luis9@ua.pt

Atmospheric rivers (ARs) are long, transient, and narrow corridors of strong transport of water vapour that, on average, carry more than double of the Amazon River flow. They are an important component of Earth's hydrological cycle transporting moisture and heat from the tropics to higher latitudes, often leading to intense precipitation. Recent studies found that ARs may also be associated with the transport of aerosols. This motivated the application of the AR concept to aerosols, introducing the term aerosol atmospheric river (AAR) into the literature. While the impacts of ARs on precipitation in the Iberian Peninsula (IP) are well-known, their role in aerosol transport towards the IP and their relationship with AARs have not yet been studied. Therefore, the goal of this work is to better understand the transport of aerosols by ARs and AARs to the IP. In this scope, a modified version of an algorithm initially designed for AR detection was applied to the Modern-Era Retrospective analysis for Research and Applications, version 2 (MERRA-2) reanalysis, to identify the ARs and AARs that impacted the IP in the period 2003-2022. Five aerosol types were analysed: sea salt, organic carbon, black carbon, sulphate, and dust. The results show that the ARs and AARs affecting the IP co-occur in a considerable proportion of the time, with more than 80% of the AR events associated with at least one type of AAR. Black carbon is the type of AAR most frequently associated with ARs, while sea salt is the type found less often during AR events. Each aerosol type has a different AAR seasonal cycle, with the more intense AARs of dust recorded during the spring months, organic carbon AARs during the summer months, and sea salt AARs during the winter months. The results also exhibit differences in the trajectory and in the region of the IP affected by AARs, depending on the type of aerosol. These findings highlight the role of ARs in the transport of aerosols and the need for an in-depth study of each aerosol type.

Which topic best fits your talk?:

Climate and Environment

153

Study of Hydrogen Impurities on NdFeO3

Author: Muhammad Aasim[1]

Co-authors: Apostols G. Marinopoulos ; Estelina da Silva ; Joaquim Agostinho Moreira ; Mariana M. Gomes ; Rui Vilarinho ; Rui Vilão

[1] *PhD Physics Student at IFIMUP - Faculty of Science of the University of Porto*

Corresponding Authors: estelina.silva@fc.up.pt, aasimghafoor1@gmail.com

INTRODUCTION
Rare-earth orthoferrites, such as NdFeO3, exhibit intricate magnetic and structural transitions, making them compelling for spintronics and optoelectronic applications. NdFeO 3 undergoes a spin-reorientation transition (SRT) between 170 K and 100 K, accompanied by symmetry changes from orthorhombic (Pbnm) to monoclinic ($P2_1/c$). This work explores these phenomena and their implications, leveraging both experimental data (1-3) and first-principles calculations. The inclusion of hydrogen impurities and their behavior further adds novelty, offering insights into local environments and structural transitions relevant to muon spin spectroscopy.

EXPERIMENTAL / THEORETICAL STUDY
The research combines experimental techniques, including Resonance Ultrasound Spectroscopy (RUS) and muon spectroscopy measurements, with computational approaches using Density Functional Theory (DFT) implemented in VASP.

Simulations incorporate Generalized Gradient Approximation (GGA), PBE+U, Hubbard U corrections, and spin-orbit coupling to examine the magnetoelastic properties, and hydrogen (H) impurity effects.

RESULTS AND DISCUSSION
Experimental results reveal a structural phase transition that occurs during SRT, with monoclinic

symmetry emerging below 170 K and disappearing by 105 K (4). This transition aligns with the observed elastic constant softening (related to the acoustic frequency softening at the zone-boundary) and spin reorientation of the Fe magnetic states from the c-axis to the a-axis. Computational studies will corroborate these findings, elucidating the role of hydrogen impurities in modifying elastic properties during SRT. Preliminary simulations by including the H impurity will support muon spectroscopy observations, where evidences of a structural phase transition can definitely now be established.

CONCLUSION
This study bridges experimental observations and theoretical predictions, elucidating the SRT and structural phase transitions in NdFeO3. By incorporating H impurities and analyzing the magnetoelastic coupling, this work advances the understanding of rare-earth orthoferrites' properties. Future research will focus on high-pressure behaviors for potential spintronic applications.

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ACKNOWLEDGMENTS
The authors acknowledge FCT for projects LA/P/0095/2020, UIDP/04968/2025 and UIDB/04968/2025, DrivenPhonon4Me- 2022-03564 PTDC, and 2022.00082. CEECIND (HYDROCAT). The authors recognize the provided HPC resources from projects POR026PROD/epor029 to access MareNostrum05 (BSC), and EHPC-BEN-2024B04-044 to access Leonardo (CINECA).

Which topic best fits your talk?:

Condensed Matter Physics and Nanomaterials

166

Color centers in diamond for neuronal signalling studies: Fabrication and transient signalling detection

Author: João Silva[1]

Co-authors: Paulo V. S. Marques [2]; Jana B. Nieder [3]

[1] *Faculdade de Ciencias da Universidade do Porto*

[2] *INESC TEC, CAP –Centre for Applied Photonics, Rua do Campo Alegre 687, Porto, Portugal*

[3] *INL - International Iberian Nanotechnology Laboratory, Ultrafast Bio- and Nanophotonics group, Av. Mestre José Veiga s/n, Braga, Portugal*

Corresponding Authors: psmarque@fc.up.pt, jpcsjoaopaulo@gmail.com, jana.nieder@inl.int

Non-invasive, high-resolution detection of neuronal activity remains a key challenge in neuroscience and bioimaging. Nitrogen-vacancy (NV) center magnetometry is a promising quantum sensing technology capable of detecting the weak magnetic fields generated by neuronal currents.A key requirements to obtain good quantum sensors with optimal properties is the fabrication. While ion implantation is the dominant method, laser irradiation has shown promising but is still comparatively less explored.˜
In the first part of this talk, I present the creation of NV centers using a 500 kHz, 515 nm laser in a single step process with no separate seed/vacancy diffusion pulses and no annealing step. By varying energy per pulse, laser exposure time and depth, we identify how this parameters affect the writing process and the impact of other laser writing processes such as graphitization, ablation and self-focusing.
In the second part, we present a novel approach using bias-free, single-frequency continuous-wave

optically detected magnetic resonance (CW-ODMR) to enable sensitive, non-invasive neuronal signal detection with single-cell resolution using a commercial diamond. By removing the bias magnetic field, we avoid perturbing natural neuronal behavior, enhancing biocompatibility. Restricting detection to a single frequency further reduces acquisition time, enabling fast imaging. Our method achieves a temporal resolution of 0.2 ms. We validated our system using a biomimetic gold wire model, applying a 5 V, 2 ms stimulus. A reproducible 1% contrast was observed in single-shot measurements, clearly correlating with the input signal. We also present analysis of signal origin, contrast sensitivity, and system limitations.
Together, these studies advance both the fabrication and application of NV centers paving the way toward real-time quantum bioimaging tools with high sensitivity and resolution.

Which topic best fits your talk?:

Optics and Photonics

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Local Probing of Structural Distortions in Ca2Mn1−xTixO4 Negative Thermal Expansion Materials

Author: Antonio Duarte Neves Cesario[1]

[1] *Universidade do Porto (PT)*

Corresponding Author: antonio.duarte.neves.cesario@cern.ch

In this study, we investigate the nanoscopic structural properties of Ca2Mn1-xTixO4 Ruddlesden-Popper (RP) perovskites combining experimental and computational approaches. Atomic-scale measurements were conducted at ISOLDE/CERN with Perturbed Angular Correlation (PAC) spectroscopy with 111mCd (48 min) probes at substitutional Ca-sites [1]. This method has provided insights into structural phase transitions (10-1200K) and Mn/Ti site distributions across different compositions, with Density Functional Theory (DFT) calculations playing a crucial role in interpreting the experiments.

Our findings indicate that incorporating Ti into the Ca2MnO4 lattice creates two distinct local environments rather than a continuous Electric Field Gradient (EFG) distribution. This arises from the reduced number of Mn/Ti nearest neighbors, which limits the possible local configurations when compared to the simple ABO3 perovskites, where the A-cations have eight equidistant B-cations. PAC spectroscopy, with its sensitivity to atomic-scale variations, effectively resolves these site-specific interactions and cation ordering. By shedding light on the structural organization within the CaO rocksalt layer, this study advances our understanding of local structural effects in RP perovskites.

Beyond this specific system, our findings have broader implications for materials exhibiting correlated electronic and structural properties. PAC proves to be a valuable tool for distinguishing subtle local environments, making it relevant for studying similar layered perovskites. These materials are of practical interest due to their tunable properties, including superconductivity, magnetoelectric coupling, and negative thermal expansion [2]. Chemical substitution, as explored in this work, offers a pathway to optimize, control or even combine these effects in solid solutions [3].

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[3] C. Ablitt et al., Front. Chem. 6, 455 (2018), ISSN 2296-2646.

Which topic best fits your talk?:

Condensed Matter Physics and Nanomaterials

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Hybrid Nanostructured Electrochemical Sensor for Microcystin-LR Determination in Water

Author: Tiago Moura[1]

Co-authors: Laura M. Salonen [2]; Nuno Santos [3]; Raquel Queirós [4]

[1] *University of Aveiro*

[2] *CINBIO, Universidade de Vigo, Department of Organic Chemistry*

[3] *i3N, Institute for Nanostructures, Nanomodelling and Nanofabrication, Department of Physics, University of Aveiro*

[4] *INL, International Iberian Nanotechnology Laboratory*

Corresponding Authors: nfsantos@ua.pt, tap.moura@ua.pt, lauramaria.salonen@uvigo.gal, raquel.queiros@inl.int

Microcystin-LR (MC-LR) is a biotoxin produced by several cyanobacteria. It is present in different aquatic environments and is not easily removed from water by conventional treatments. In this way, humans are primarily exposed to MC-LR via drinking water, creating multiple health risks such as poisoning, hepatoxicity, tumor promotion and reproductive issues [1], [2]. Consequently, the World Health Organization has established a limit of 1 µgL-1 for MC-LR in drinking water.

Analytical methods based on chromatography and mass spectrometry, as well as the common enzyme-linked immunosorbent assay (ELISA), tend to be reliable for the determination of microcystins, providing high sensitivity and low detection limits. However, they require sizable equipment that cannot perform real-time analysis. To fulfill such needs, extensive research has been conducted on the development of electrochemical sensing platforms. Electrochemical sensors are cost-effective, efficient alternatives for in situ monitoring in a timely manner [3].

Herein, a hybrid nanostructure based on a laser-induced graphene (LIG) [4] transducing surface integrated with covalent organic frameworks (COFs) [5] as selective recognition moieties is proposed to overcome the challenges associated with low-concentration, selective MC-LR electrochemical sensing. LIG electrodes were patterned on polyimide substrates through direct laser irradiation, and the surfaces'morphology, structure, conductivity and electrochemical properties were characterized and optimized for the intended application. Thereafter, the in situ growth of a COF on the LIG surface was studied. The morphological and chemical characterization indicated the formation of a rough COF film. Subsequently, the determination of MC-LR with the COF/LIG hybrid nanostructure was achieved through an indirect strategy. Firstly, the modified electrodes were incubated with different concentrations of MC-LR to promote the adsorption of the biotoxin to the COF/LIG surface. Thereafter, the electrodes were immersed in solutions of [Fe(CN)6]3-/4- and cyclic voltammograms were acquired. As the adsorbed MC-LR inhibits the redox signal from the [Fe(CN)6]3-/4-, a relationship between redox peak current and MC-LR concentration can be established.

Which topic best fits your talk?:

Condensed Matter Physics and Nanomaterials

164

Assessing dust aerosol-radiation-cloud interactions using different WRF-Chem model run approaches: a case study over the Iberian Peninsula

Author: Rui Silva[1]

Co-authors: Ana Cristina Carvalho [2]; Alfredo Rocha [1]

[1] *Department of Physics and Centre for Environmental and Marine Studies (CESAM) Campus Universitário de Santiago, University of Aveiro, 3810-093 Aveiro, Portugal*

[2] *Swedish Meteorological and Hydrological Institute, SMHI FoUmmk, 601 76 Norrköping, Sweden*

Corresponding Authors: alfredo.rocha@ua.pt, ruipedrosilva@ua.pt, ana.carvalho@smhi.se

Meteorological re-initialization with chemistry recycling and spectral nudging above the planetary boundary layer have been frequently used simulation techniques in online coupled meteorology-atmospheric chemistry regional models to study aerosol-radiation-cloud interactions. While these model-running methods may reduce meteorological drifting from the observed atmospheric state, their impact on simulated aerosol feedbacks remains poorly understood. In this study, the Weather Research and Forecasting model coupled with Chemistry (WRF-Chem) is used to evaluate the influence of both run approaches on simulated aerosol interactions during an extreme dust event that affected the Iberian Peninsula between 7 and August 12, 2010. To evaluate the model's ability to simulate key atmospheric parameters for aerosol feedback modelling, the simulated global, direct, and diffuse radiation components, as well as aerosol optical and cloud microphysical properties, are compared with multiple satellite-based products. Furthermore, the impact of each simulation approach and of dust aerosol on direct, semi-direct, and indirect effects is also explored.

Which topic best fits your talk?:

Climate and Environment

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On the space of U(N) scattering amplitudes

Author: Ricardo Almeida Rodrigues[1]

Co-author: Lúcia Córdova

[1] *University of Porto*

Corresponding Author: up201805119@edu.fc.up.pt

We investigate the space of massive two-dimensional theories with a global U(N) symmetry and no bound states. Following S-matrix bootstrap principles, we establish rigorous bounds on the space of consistent $2 \longrightarrow 2$ scattering amplitudes. The allowed regions exhibit rich geometric features with integrable models appearing at special points along the boundary.
Generic extremal amplitudes display an infinite number of resonances and periodic behavior in energy, similar to previous studies with other group-like symmetries. Within the allowed space, we identify a subregion where the symmetry is enhanced to O(2N), establishing a connection with earlier studies. We also revisit the classification of integrable solutions, identifying one that was previously overlooked in the literature. Finally, we examine the walking behavior of the central charge associated with several of these periodic amplitudes.

Which topic best fits your talk?:

High Energy Physics and Cosmology

162

Cyclodipeptides based composite electrospun nanofibers for Energy Harvesting Applications

Author: Daniela Santos[1]

Co-authors: Bernardo Almeida [2]; Francis Leonard Deepak [3]; Rosa Baptista [2]

[1] *University of Minho - CFUM and INL*

[2] *CFUM*

[3] *INL*

Corresponding Authors: bernardo@fisica.uminho.pt, id11280@alunos.uminho.pt

The production of functional materials derived from dipeptides is gaining significant attention in bionanotechnology due to their biocompatibility, structural rigidity, versatile morphologies, and ease of functionalization and synthesis [1]. Cyclodipeptides are an emerging group of ring-shaped dipeptides, that exhibit the unique ability to dimerize into quantum dots which, self-assemble into supramolecular structures with different morphologies (nanospheres, nanotubes, nanowires, nanofibers) showing quantum confinement and photoluminescence [2]. Amino acids, the building blocks of dipeptides, exhibit chirality [1]. Their non-centrosymmetric structure enables spontaneous polarization and/or ferroelectricity, which is the basis of piezoelectric and pyroelectric effects with applications in optoelectronics and beyond. As a result, cyclodipeptides hold great potential for applications in biological tissue imaging and piezoelectric microdevices [2].
Electrospinning is a widely used technique for creating nano- or microfibers by utilizing an electric field to draw and elongate a polymer solution into ultrafine fibers. This method also facilitates the functionalization of polymer matrices with active materials to achieve desired properties. As cyclodipeptides exhibit high thermal stability and mechanical strength, in our work, we utilized these properties to make nanofiber systems incorporating dipeptides into PVDF nanofibers. In this respect, poly(vinylidene fluoride) (PVDF) is a widely used semicrystalline polymer known for its exceptional pyroelectric and piezoelectric properties. These characteristics make it an ideal material for use in combinations with the cyclodipeptides, to produce composite nanofibers for piezoelectric energy harvesters, sensors, and nanogenerators.
The obtained nanofibers containing self-assembled nanostructures embedded into the polymer matrix, are wide-band gap semiconductors with 4.0 eV bandgap energy. We studied their structural, morphological, optical, piezoelectric and pyroelectric responses, towards hybrid systems for energy generation and built a prototype energy harvesting system.

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Which topic best fits your talk?:

Condensed Matter Physics and Nanomaterials

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Domain wall evolution beyond quartic potentials: The Sine-Gordon and Christ-Lee potentials

Authors: Ricarda Heilemann[1]; Manuel Rosa[None]; José Ricardo Correia[None]; Carlos Martins[None]

[1] *Centro de Astrofísica da Universidade do Porto*

Corresponding Author: ricarda.heilemann@astro.up.pt

Domain walls are the simplest type of topological defects formed at cosmological phase transitions, and one of the most constrained. Their studies typically assume a quartic double well potential, but this model is not fully representative of the range of known or plausible particle physics models. Here we study the cosmological evolution of domain walls in two other classes of potentials. The Sine-Gordon potential allows several types of walls, interpolating between different pairs of mínima (which demands specific numerical algorithms to separately measure the relevant properties of each type). The Christ-Lee potential parametrically interpolates between sextic and quartic behavior. We use multiple sets of simulations in two and three spatial dimensions, for various cosmological epochs

and under various choices of initial conditions, to discuss the scaling properties of these networks. In the Sine-Gordon case, we identify and quantify deviations from the usual scaling behavior. In the Christ-Lee case, we discuss conditions under which walls form (or not), and quantify how these outcomes depend on parameters such as the energy difference between the false and true vacua and the expansion rate of the Universe. Various biased initial conditions are also addressed in fappendices. Finally, we briefly comment on the possible cosmological implications of our results.

Which topic best fits your talk?:

High Energy Physics and Cosmology

173

Harnessing Light for Computing: Neuromorphic Architectures and Analogue Photonic Platforms

Author: Vicente Rocha[None]

Corresponding Author: vicentevrocha.vvr@gmail.com

Optical computing has long been regarded as a promising avenue for fast and energy-efficient information processing. The field has already made significant contributions to modern technology by enhancing performance in specialized tasks such as matrix-matrix multiplication, Fourier transforms, and convolutions. Despite these successes, the development of an optical algorithm capable of addressing a broader range of problems remains a challenge, motivating the search for alternative computation frameworks that exploit the unique advantages of light. A promising pathway lies in the development of photonic neuromorphic devices. By encoding memory through the linear weights of the network and exploiting the universal function approximation capabilities of neural networks, this approach offers a versatile and scalable framework for analog optical computing.

In this direction, we investigate Photonic Extreme Learning Machines (PELMs), a class of architectures inspired by the Extreme Learning Machine (ELM) algorithm. According to the ELM theory, the random initialization of hidden-layer weights and biases, together with nonlinear and non-polynomial activation functions, is sufficient to guarantee universal function approximation. In the optical domain, the bypass of weight training results in improved energy-efficiency and robustness to noise. This paradigm has been implemented in diverse configurations, ranging from free-space propagation to tunable integrated optics. However, a comprehensive theoretical model capable of describing these systems and capabilities remains absent. In our work, we develop such a model and establish its correspondence with ELM theory, enabling the identification of the computational role of individual optical components and highlighting current limitations and opportunities for future development.

Another front of our research addresses the weak nonlinearities of optical systems. To this end, we investigate the dynamics of light in nonlinear media, where self and cross-interaction between beams give rise to rich nonlinear behaviour. In particular, we focus on Fluids of Light, a paraxial propagation regime that exhibits close analogies with quantum fluids. From superfluidity to turbulence and the Kolmogorov energy cascade, as well as vortex generation, these systems host exotic phenomena with largely unexplored potential for computation. Our work explores how geometrical properties of refractive-index landscapes can be engineered to control the input–output response of light. Currently, we are validating our experimental platform by reproducing reported results on light localization in photonic Moiré lattices. In contrast with other optical configurations, our approach leverages Spatial Light Modulators (SLMs) to independently modulate the amplitude and phase (velocity) of input states of light, thereby providing an additional level of tunability and versatility.

Which topic best fits your talk?:

Optics and Photonics

High Energy Physics & Cosmology II (Chair: TBD) / 175

Instability of Q-Hairy Black Holes

Authors: Carlos Herdeiro[1]; Eugen Radu[1]; José Ferreira[1]; Miguel Zilhão[1]

[1] *University of Aveiro*

Corresponding Author: jpmferreira@ua.pt

GW observations in the last decade have reinforced the Kerr BH paradigm, but these conclusions rely on waveform catalogs dominated by Kerr BH. Expanding the diversity of modeled sources is essential to uncover potential new physics. However, only bodies whose stability is known can become viable alternatives. Here, we study the stability of Q-hairy BHs, solutions in the Einstein-Maxwell-Scalar model that evade well-known uniqueness theorems.

Which topic best fits your talk?:

Astrophysics