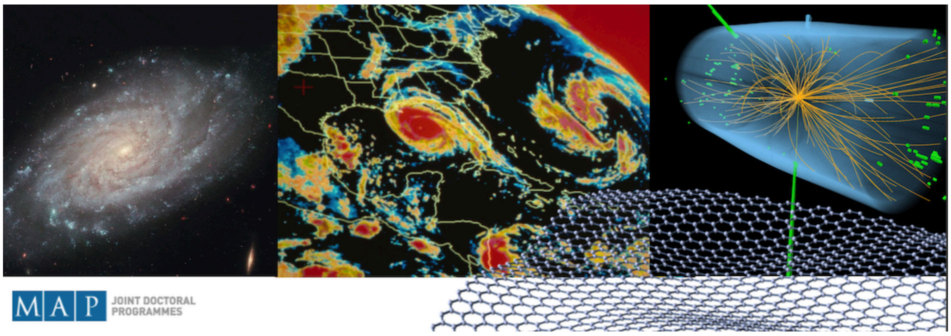
MAP-Fis Research Conference

Friday 11 October 2024 - Friday 11 October 2024

University of Aveiro



Book of Abstracts

Contents

Hot-electron model for graphene: the key to understanding pump-probe experiments . . 1

Room temperature photon emitters in hexagonal boron nitride films grown by atmospheric-pressure chemical vapor deposition 1

Ferroelectric polarization and switching pathways of doped Hf/ZrO2 2

Charge transport mechanisms of topological insulator Bi2Se3 for Photo Galvanic Applications 3

Gravitational waves from supercooled phase transitions in conformal Majoron models . 4

Probing freeze-in via invisible Higgs decay 4

Bootstrapping U(N) S-matrices 5

Holographic five-point functions with arbitrary weight 5

Hubble tension in a nonminimally coupled curvature-matter gravity model 5

Hypershadows of higher dimensional black objects 6

Probing first interaction properties of ultra high energy cosmic rays by measuring the low muon number distribution tail using underground muon detectors 6

Covalent Organic Framework/Laser-Induced Graphene Hybrid Nanostructured Electrochemical Sensor for Sulfamethoxazole Determination 7

Selective higher order mode excitation in a nanoprinted hollow square-core waveguide . 8

Numerical tests of the large charge expansion 8

Development of a quality control and calibration instrument for Rangefinders/LiDARs . 9

Searching for dark matter with the ATLAS detector using unconventional signatures . . 10

Color centers in diamond for neuronal signaling studies - 2 years in 11

Using Machine Learning to Scan Beyond Standard Model Parameter Spaces 11

Self-interactions can (also) destabilize bosonic stars 12

Testing the performance of six PBL Parameterizations under six Weather Types in Portugal 12

THE NON-SPHERICAL GROUND STATE OF PROCA STARS 13

Future climate wildfire modelling using the atmophere-fire coupled model WRF-SFIRE, under different landscape management scenarios. 13

The Born regime of gravitational amplitudes 14

Impact of dry deposition on WRF-Chem model results and size-resolved AOD during dust event over the Iberian Peninsula 14

NRSurNN3dq4: A Deep Learning Powered Numerical Relativity Surrogate for Binary Black Hole Waveforms 15

TBounce: gravitational wave computations for primordial phase transitions 16

Condensed Matter Physics and Nanomaterials I (Chair: Luís Carlos, Universidade de Aveiro) - Anf. Física (13.1.19) / 118

Hot-electron model for graphene: the key to understanding pump-probe experiments

Authors: Diogo Cunha[1]; Mikhail Vasilevskiy[None]; Rui Dias[None]; Manuel Rodrigues[None]

[1] *Universidade do Minho*

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

Pump-probe spectroscopy is a nonlinear technique utilized to investigate the dynamics of ultrafast electrons [1]. This method involves focusing a short pulse of a strong pump beam and, after a certain delay time, a weak probe beam on a sample to record its transmittance, influenced by the pump. In the majority of experiments targeting nonlinear optical phenomena, such as the pump-probe spectroscopy, the application of high-intensity pulses drives graphene into a strongly non-equilibrium state [2]. Under these conditions, conventional perturbation theory falls short in explaining graphene's intricate optical response due to significant deviations in electron distribution over energy states from the equilibrium Fermi-Dirac one [3].
In this work, we present a hot-electron model capable of predicting the transient dynamics of graphene's carriers out of equilibrium, from the generation of spectrally narrow populations of non-thermalized electrons and holes to the establishment of a hot-electron gas and its subsequent relaxation towards equilibrium with the crystal lattice [4]. Additionally, we incorporate the modelling of the nonlinear cross-phase modulation (XPM) effect in a glass slab, which can serve as a substrate for the graphene layer. Our calculations reproduce well the XPM pattern in the differential transmittance spectrum of glass and clearly show that there is another (beyond XPM) mechanism of pump-probe interaction in graphene.
By comparing our model calculations to experimental results, we demonstrate the reliability and relevance of the hot-electron model to pump-probe experiments, providing insights into the pivotal role of hot electrons in comprehending ultrafast dynamics in graphene.

[1] M. Fushitani, Annu. Rep. Prog. Chem. Sect. C: Phys. Chem. 104 (2008) 272.
[2] T. Li et al., Phys. Rev. Lett. 108 (2012) 167401.
[3] S.A. Mikhailov, Phys. Rev. B 100 (2019) 115416.
[4] D.F.P Cunha, R. Dias, M.J.L.F Rodrigues, M.I. Vasilevskiy, Appl. Sci. 14 (2024) 1250.

Which topic best fits your talk?:

Condensed Matter Physics and Nanomaterials

Condensed Matter Physics and Nanomaterials I (Chair: Luís Carlos, Universidade de Aveiro) - Anf. Física (13.1.19) / 127

Room temperature photon emitters in hexagonal boron nitride films grown by atmospheric-pressure chemical vapor deposition

Author: Elmahdi Amar[1]

Co-author: Tiago Queirós [1]

[1] *INL + U Minho*

Corresponding Authors: tiago.queiros@inl.int, elmahdi.amar@inl.int

Hexagonal boron nitride (h-BN) is a promising two-dimensional material due to its properties, such as high thermal conductivity and excellent thermochemical stability (1). h-BN can host numerous

optically structural defects (2,3). The production of h-BN films on Cu foil using an ammonia borane (NH_3BH_3) precursor is investigated. The growth is performed via atmospheric-pressure chemical vapor deposition (APCVD), with two heating zones under a mixture (Ar:H_2) flow rate of (95:5) sccm. h-BN films are then transferred onto SiO_2/Si, sapphire, and glass substrates via a wet chemical method. According to X-ray photoelectron spectroscopy studies, the preliminary tests performed for low and high flux of argon used during the AB pre-treatment show similar surface chemical compositions in the produced h-BN films. A large-area h-BN film (1 cm^2) with a thickness of 7 nm is confirmed by atomic force microscopy and X-ray reflectivity experiments. The optical properties of h-BN films are derived from the analysis of the transmittance and reflectance curves. The band-gaps estimated are between 3.58 and 4.55 eV. Fluorescent spots observed in h-BN thin films in the wavelength range of 520 to 690 nm exhibit a blinking effect with "ON" and "OFF" states (Figure 1). These studies will enable the optimization of h-BN growth, aiming to get high-quality h-BN for future optoelectronic applications.

Which topic best fits your talk?:

Condensed Matter Physics and Nanomaterials

Condensed Matter Physics and Nanomaterials I (Chair: Luís Carlos, Universidade de Aveiro) - Anf. Física (13.1.19) / 135

Ferroelectric polarization and switching pathways of doped Hf/ZrO2

Author: Alexandre Silva[None]

Co-authors: Luis Marques [1]; Veniero Lenzi [2]

[1] *Universidade do Minho*

[2] *Universidade de Aveiro, CICEO*

Corresponding Authors: veniero.lenzi@fisica.uminho.pt, alexandredmfs@gmail.com, lsam@fisica.uminho.pt

Hf/ZrO_2 -based ferroelectric (FE) thin films provide increasingly promising technical solutions for extensive application in low-power and high-speed memory due to its CMOS-compatibility and high scalability. Ferroelectricity in Hf/ZrO_2 thin films arises from the polar orthorhombic $Pca2_1$ phase (o-phase), while in bulk the stable phases are the monoclinic $P2_1/c$ phase (m-phase) around room temperature and the tetragonal $P4_2/nmc$ phase (t-phase) at high temperature, which are both centrosymmetric showing no ferroelectric behavior.

It has been reported that several effects, such as strain, dopants, oxygen vacancies, capping layers, etc, facilitate the o-phase formation. However, wake-up effect, imprint, fatigue, and endurance are still drawbacks hindering the commercialization of these devices. Doping has recently emerged as one of the most promising tools to tune the ferroelectric properties of Hf/ZrO_2 thin films. However, a comprehensive study of the effects of different dopants on structural, ferroelectric switching and piezoelectric properties of Hf/ZrO_2 is still widely missing.

Therefore, in this work, we provide novel first principles evidence using density functional theory (DFT) and ab initio molecular dynamics (AIMD) calculations of the effect of dopants on the polarization, piezoelectric response, relative phase stability and phase transition temperatures of ZrO_2. Furthermore, we use DFT calculations to assess the distinct influences of the presence of La-doping and parasitic non-FE interfaces on the switching mechanisms of HfO_2 thin films.

We reveal that Si, B and Al doping can enhance the spontaneous polarization magnitude in ZrO_2. In addition, we show first principles evidence of Si promoting the t-phase, and also that Al doping offsets the phase transition temperature causing an enlarged piezoelectric response. We show also that both the presence of o/m interfaces and La doping contribute to a lower coercive field for switching.

Which topic best fits your talk?:

Condensed Matter Physics and Nanomaterials

Condensed Matter Physics and Nanomaterials I (Chair: Luís Carlos, Universidade de Aveiro) - Anf. Física (13.1.19) / 132

Charge transport mechanisms of topological insulator Bi2Se3 for Photo Galvanic Applications

Author: James Caleb Peters[1]

Co-authors: Daniel Brito [1]; Sascha Sadewasser [2]; Jerome Borme [3]; Francis Leonard Deepak [2]; Pedro Alpuim [4]

[1] *PhD Student*

[2] *Research Group Leader*

[3] *Staff Researcher*

[4] *CFUM and INL, Braga, Portugal*

Corresponding Authors: james.peters@inl.int, palpuim@fisica.uminho.pt

Topological insulators have attracted researchers'attention recently due to their unique surface states protected by time-reversal symmetry [1-5]. Since Bi2Se3 has a low bandgap, it is expected to perform well in photodetection for visible and infrared optoelectronics [6, 7]. Here, we present the preliminary results from our work on the growth, cleanroom fabrication, and characterization of Bi2Se3 photodetectors. The Bi2Se3 was grown on a sapphire substrate by molecular beam epitaxy (MBE). The Raman modes at 72 cm-1, 132 cm-1, and 175 cm-1 correspond to the A11g, E2g, and A21g vibrational modes, confirming the presence of Bi2Se3. A Focused Ion Beam (FIB) was used to prepare the lamellas of Bi2Se3 for their further detailed analysis by HAADF-STEM imaging and spectroscopy. High-resolution HAADF-STEM images show that the Bi2Se3 is highly oriented in the (0001) crystallographic direction. The quintuple layers of Bi2Se3 (Se-Bi-Se-Bi-Se) were observed in the [110] crystallographic direction. The devices were fabricated using microfabrication techniques inside the cleanroom with Cr/Au contacts. The devices'channel lengths range from 4 to 12 µm. I-V curves were measured with a Keithley 2400 source meter in the dark. The results show that the devices generally follow an ohmic behavior, confirming a good contact formation. Some of the device's contacts show Schottky diode behavior. DC conductivity was measured using a Lakeshore Cryo-Probe station as a function of temperature down to 6.5 K. Results from the Arrhenius plot show that the device has four different charge transport mechanisms. At high temperatures, the devices follow the Arrhenius equation with activation energy half of the band gap. In moderate temperatures, the conductivity follows an activated hopping mechanism, with very low activation energy suggesting the formation of charge puddles. At lower temperatures, the devices follow Efros-Shklovski law.

References

[1] M. Fruchart, D. Carpentier, C R Phys. 14 (2013) 779-815.
[2] M.Z. Hasan, C.L. Kane, Rev. Mod. Phys. 82 (2010) 3045-3067.
[3] Q. Qiu, Z. Huang, Adv. Mater. 33 (2021) 2008126.
[4] Q. Wang, X. Wu, L. Wu, Y. Xiang, AIP Adv. 9 (2019) 025022.
[5] J.D. Yao, J.M. Shao, S.W. Li, D.H. Bao, G.W. Yang, Sci. Rep. 5 (2015) 14184.
[6] W. Tang, A. Politano, C. Guo, W. Guo, C. Liu, L. Wang, X. Chen, W. Lu, Adv. Funct. Mater. 28 (2018) 1801786.
[7] X. Hong, J. Shen, X. Tang, Y. Xie, M. Su, G. Tai, J. Yao, Y. Fu, J. Ji, X. Liu, J. Yang, D. Wei, Opt. Mater. 117 (2021) 111118.

Which topic best fits your talk?:

Condensed Matter Physics and Nanomaterials

High Energy Physics and Cosmology I (Chair: António Onofre, Universidade do Minho) - Anf. Física (13.1.19) / 112

Gravitational waves from supercooled phase transitions in conformal Majoron models

Author: João Pedro Pino Gonçalves[1]

Co-authors: António P. Morais [1]; Danny Marfatia [2]; Roman Pasechnik [3]

[1] *University of Aveiro*

[2] *University of Hawaii*

[3] *University of Lund*

Corresponding Author: jpedropino@ua.pt

Despite the shortcomings of the Standard Model, all experimental observations so far have not indicated the existence of new physics (NP) at or near the TeV scale. The gravitational channel is another promising avenue to test NP and can potentially probe particles with masses far beyond those accessible at current collider experiments. With this in mind, we perform a phenomenological study of supercooled phase transitions within a conformal Majoron-like model in a generic U(1) charge assignment setting, where neutrino masses and mixings are generated through a type-I seesaw mechanism. Such transitions are extraordinary candidate scenarios to be tested at GW interferometers due to the significant amount of released latent heat and the long-lasting nature of the phase transition. This is expected to result in a stochastic graviational wave background with a large energy density amplitude, well within the detection capabilities of existing and future experiments. Considering a broad range of masses from the TeV to the GUT-scale, we discuss the phenomenological implications for this class of models at LISA and LIGO O5, as well as how current data from LIGO-Virgo-Kagra data can already exclude part of the parameter space.

Which topic best fits your talk?:

High Energy Physics and Cosmology

High Energy Physics and Cosmology I (Chair: António Onofre, Universidade do Minho) - Anf. Física (13.1.19) / 115

Probing freeze-in via invisible Higgs decay

Authors: Vinicius Oliveira[None]; António Morais[1]; Oleg Lebedev[None]; Roman Pasechnik[2]

[1] *University of Aveiro*

[2] *Lund university*

Corresponding Authors: roman.pasechnik@thep.lu.se, aapmorais@ua.pt, vinicius.lb.oliveira@gmail.com, oleg.lebedev@helsinki.fi

We explore the implications of low reheating temperatures in the early Universe, focusing on scenarios where a minimal threshold of 4 MeV is crucial to preserve the accuracy of Big Bang Nucleosynthesis (BBN) predictions. We specifically investigate the freeze-in mechanism, wherein Dark Matter (DM) candidates are Boltzmann suppressed due to their mass exceeding the reheating temperature. Building upon previous research demonstrating the efficacy of this approach, particularly in achieving the correct abundance of DM, our exploration extends to lower reheating temperatures, necessitating a lighter DM mass. Furthermore, we incorporate the contribution of mesons post-Quantum Chromodynamics (QCD) phase transition, wherein quarks transition into bound states, facilitating DM production via the Higgs portal. Our findings shed light on the viability of such scenarios and their implications for understanding the early Universe and the nature of dark matter.

Which topic best fits your talk?:

High Energy Physics and Cosmology

High Energy Physics and Cosmology I (Chair: António Onofre, Universidade do Minho) - Anf. Física (13.1.19) / 119

Bootstrapping U(N) S-matrices

Author: Ricardo Almeida Rodrigues[1]

[1] *University of Porto*

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

We analyze two-dimensional scattering matrices for particles transforming in the fundamental representation of the U(N) global symmetry group, assuming no bound states. In particular, we use the S-matrix bootstrap formalism to construct the allowed space of S-matrices for such processes, which in turn need to be consistent with the usual conditions of unitarity, crossing and analyticity. Analogously to the O(N) case studied in 1909.06495, we find that certain points at the boundary of this surface correspond to integrable models.

Which topic best fits your talk?:

High Energy Physics and Cosmology

High Energy Physics and Cosmology I (Chair: António Onofre, Universidade do Minho) - Anf. Física (13.1.19) / 121

Holographic five-point functions with arbitrary weight

Author: Carlos Bruno Dias Fernandes[None]

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

Conformal field theories (CFTs) are a subset of quantum field theories which are invariant under conformal transformations. CFTs are of great theoretical interest, partly due to the AdS/CFT conjecture, which asserts that a gravitational theory living in d-dimensional Anti-de Sitter (AdS) space is dual to a CFT on the $(d-1)$-dimensional boundary of this space. This is a powerful correspondence, since it allows us to use powerful machinery available for CFTs to extract results about theories with gravity. In this talk, I will discuss ongoing work on the computation of scalar correlators in a particular CFT known as $\mathcal{N} = 4$ supersymmetric Yang-Mills theory, in the strong coupling regime. Although four-point functions have been extensively studied in this regime, only a few specific five-point functions are known.The goal of this project is to extend the study of these five-point functions, which encode new information about the AdS dual theory.

Which topic best fits your talk?:

High Energy Physics and Cosmology

High Energy Physics and Cosmology I (Chair: António Onofre, Universidade do Minho) - Anf. Física (13.1.19) / 122

Hubble tension in a nonminimally coupled curvature-matter gravity model

Author: Miguel Barroso Varela[None]

Co-author: Orfeu Bertolami [1]

[1] *University of Porto*

Corresponding Authors: up201907272@edu.fc.up.pt, orfeu.bertolami@fc.up.pt

The presently open problem of the Hubble tension is shown to be removed in the context of a modified theory of gravity with a non-minimal coupling between curvature and matter. By evolving the cosmological parameters that match the cosmic microwave background data until their values from direct late-time measurements, we will show how to obtain an agreement between different experimental methods without disrupting their individual validity. These modified gravity models are shown to provide adequate fits for other observational data from recent astrophysical surveys and to reproduce the late-time accelerated expansion of the Universe without the inclusion of a cosmological constant. This talk is based on the work conducted in JCAP06(2024)025 (arXiv:2403.11683).

Which topic best fits your talk?:

High Energy Physics and Cosmology

High Energy Physics and Cosmology I (Chair: António Onofre, Universidade do Minho) - Anf. Física (13.1.19) / 129

Hypershadows of higher dimensional black objects

Authors: Carlos Herdeiro[None]; João Novo[1]; Pedro Cunha[2]

[1] *Universidade de Aveiro*

[2] *Aveiro & IST Lisbon*

Corresponding Authors: herdeiro@ua.pt, cunhapcc@gmail.com, j.novo@ua.pt

What does a black hole look like? In 1 + 3 spacetime dimensions, the optical appearance of a black hole is a bidimensional region in the observer's sky often called the black hole shadow, as supported by the EHT observations. In higher dimensions this question is more subtle and observational setup dependent. Previous studies considered the shadows of higher dimensional black holes to remain bidimensional. We argue that the latter should be regarded as a tomography of a higher dimensional structure, the hypershadow, which would be the structure "seen"by higher dimensional observers. As a case study we consider the cohomogeneity-one Myers-Perry black hole in 1 + 4 dimensions, and compute its tridimensional hypershadow.

Which topic best fits your talk?:

Astrophysics

High Energy Physics & Cosmology II (Chair: Carlos Herdeiro, Universidade de Aveiro) - Sala Sousa Pinto, DM (11.2.6) / 125

Probing first interaction properties of ultra high energy cosmic rays by measuring the low muon number distribution tail using underground muon detectors

Author: Alexandra Fernandes[None]

Corresponding Author: afernandes@lip.pt

The Pierre Auger Observatory, the world's largest experiment in the study of the highest energy astroparticles, is being upgraded with new detector technologies to reduce its current systematic uncertainties and accurately determine the mass composition of Ultra High Energy Cosmic Rays (UHECRs). The Underground Muon Detector (UMD), a part of the recent low-energy extension of the observatory, has the ability to directly measure the muonic component of extensive air showers. UHE cosmic rays have long been seen as an unique opportunity to probe hadronic interaction physics at high energies. A recent analysis found that the shape of the lower tail of the muon number distribution is sensitive to the properties of multiparticle production in the first interaction of the air shower. Taking advantage of the detection capabilities of the UMD, E ⊠ 10^{17}eV, air-shower phenomenology studies are being developed in order to test first interaction properties for proton-air events at center-of-mass energies reached by the Large Hadron Collider for different hadronic interaction models.

Which topic best fits your talk?:

High Energy Physics and Cosmology

Nanomaterials, Optics & Photonics (Chair: Ariel Gurreiro, Universidade do Porto) - Anf. Física (13.1.19) / 133

Covalent Organic Framework/Laser-Induced Graphene Hybrid Nanostructured Electrochemical Sensor for Sulfamethoxazole Determination

Author: Tiago Moura[1]

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

[1] *Department of Physics, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal.*

[2] *CINBIO, Universidade de Vigo, Department of Organic Chemistry, Vigo 36310, Spain.*

[3] *i3N, Institute for Nanostructures, Nanomodelling and Nanofabrication, Department of Physics, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal.*

[4] *INL, International Iberian Nanotechnology Laboratory, Av. Mestre José Veiga, 4715-330, Braga, Portugal.*

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

Sulfonamides are a class of synthetic broad spectrum antimicrobial drugs widely used in animal farms and human medicine. Sulfamethoxazole (SMX) is the most prevalent sulfonamide and has been detected in different aquatic environments in concentrations as high as 49.7 µg L-1 [1]. The scientific community and health organizations are increasingly concerned due to the potential toxicity to environmental and human health, as well as due to the increasing awareness towards the spread of antibiotic resistant strains and antibiotic resistance genes [2], [3]. Therefore, there is a need for more effective monitoring tools. Electrochemical sensors are interesting substitutes for traditional analytical methods owing to their dimensions, ease of operation, and cost-effectiveness [4]. However, to sense low concentrations in complex matrices, several aspects must be addressed, such as transducer performance, response time, reproducibility, sensitivity, and selectivity [5].

Herein, laser-induced graphene (LIG) [6] transducing surfaces integrated with covalent organic frameworks (COFs) as selective recognition moieties are proposed to fulfil the required needs for low-concentration electrochemical sensing. LIG surfaces were fabricated through direct laser irradiation of polyimide substrates, i.e. direct laser writing [6]. The produced surfaces were extensively characterized, allowing their optimization for the intended sensing application. Thereafter, the in

situ growth of a COF based on 1,3,5-tris(4-aminophenyl)benzene (TAPB) and 2,5 dimethoxyterephthalaldehyde (DMTP) linkers [7] on LIG surfaces was studied. The morphological, structural, and chemical characterization through Raman spectroscopy and scanning electron microscopy indicated the successful formation of COF particles on the LIG surface. Subsequently, the electrochemical characterization of the modified electrodes, with the support of a typical redox probe, revealed that the COF layer does not limit the electrochemical response of the LIG electrodes. Cyclic voltammetry was also employed to assess the electrochemical behaviour of SMX towards the COF/LIG modified electrodes. The cyclic voltammograms showed the presence of an SMX oxidation peak with no corresponding reduction peak, which also evidenced the irreversibility of the electrochemical reaction. All in all, this constitutes a promising result regarding the application of the COF/LIG hybrid nanostructure as sensing platform for sulfamethoxazole in water environments.

Which topic best fits your talk?:

Condensed Matter Physics and Nanomaterials

Nanomaterials, Optics & Photonics (Chair: Ariel Gurreiro, Universidade do Porto) - Anf. Física (13.1.19) / 120

Selective higher order mode excitation in a nanoprinted hollow square-core waveguide

Author: Diana Pereira[1]

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

[1] *University of Aveiro (i3n & Physics department) & Institute of Photonic Technology (Germany)*

[2] *Leibniz Institute of Photonic Technology (Germany)*

[3] *University of Aveiro (i3n & Physics department)*

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

Tailoring the excitation of higher order modes (HOM) is of great importance across several applications within the photonics field, including optofluidics sensing, nonlinear phenomena generation, imaging, and in fiber communication systems. Nevertheless, effectively exciting specific HOM still remains a challenge.
Currently, HOM can be achieved resorting to certain optical devices such as spatial light modulators and modal couplers. However, these devices are not fully integrated in the waveguide, which can impose some drawbacks such as difficult coupling and the requirement of high precision in the alignment.
With the recent advancements in the 2-photon polymerization (2PP) printing technology, a novel methodology for the excitation of HOM can be explored. The figures of merit of this method rely on the capability of designing extremely smooth structures at a nanoscale, and with a very high detail accuracy. Thus, new platforms based on a waveguide integrated modulator are being pursuit.

Within this context, we present a reliable and highly reproducible method to effectively exciting HOM. Resorting to the 2PP technology, a nano-phase plate integrated into a nanoprinted hollow square core waveguide is proposed. The 580 nm thick phase plate is configured in two different designs, inducing the excitation of the LP11 and LP12 modes.

Which topic best fits your talk?:

Optics and Photonics

High Energy Physics & Cosmology II (Chair: Carlos Herdeiro, Universidade de Aveiro) - Sala Sousa Pinto, DM (11.2.6) / 116

Numerical tests of the large charge expansion

Author: José Guilherme Boura de Matos[1]

[1] *FCUP*

Corresponding Author: up201506054@edu.fc.up.pt

We perform Monte-Carlo measurements of two and three-point functions of charged operators in the critical O(2) model in 3 dimensions. Our results are compatible with the predictions of the large charge superfluid effective field theory. We improved the Worm algorithm to obtain reliable measurements for large charge values. We devised a measurement scheme that mitigates the uncertainties due to lattice and finite-size effects.

Which topic best fits your talk?:

High Energy Physics and Cosmology

Nanomaterials, Optics & Photonics (Chair: Ariel Gurreiro, Universidade do Porto) - Anf. Física (13.1.19) / 124

Development of a quality control and calibration instrument for Rangefinders/LiDARs

Author: Nelssom Cunha[1]

[1] *University of Minho*

Corresponding Author: ncunha@fisica.uminho.pt

A proof-of-concept test bench to assess the quality and operation of rangefinders and LiDARs in a compact setup with a footprint small enough to sit on a usual optical table. In particular, the development subsystem includes an apparatus capable of measuring the maximum range of the rangefinder type of instrument. The range measurement will be implemented by mimicking a real backscattering event that would take place in a far location and feeding back to the rangefinder a signal that is synthesized from the instrument's own illumination laser after a carefully calibrated attenuation procedure and with similar noise characteristics to one taken in an open field scenario.
The instrument consists of a rotating optical diffuser placed at the focus of an optical collimator and an optical attenuator. The maximum range of the LiDAR is calculated by a radiometric equivalence to the distant target when the LiDAR detected signal is extinguished. This subsystem is to synthesize an optical echo signal, fed from the rangefinder's own laser beam, that is meant to be similar to that that would come from a distant diffusive object. The goal is to produce an optical stimulus with high fidelity to the signal that would be acquired in a real situation and, in particular, regarding its amplitude attenuation, to preserve as much as possible the optical noise present in the real case. To do that, we use a calibrated diffused light generator that produces a diffused signal with controllable amplitude.
Also, experimental study of the physical phenomena that influence the signal-to-noise ratio in rangefinders and LiDARs, which greatly influences them, and of the coherence properties of backscattered light and how to mimic them with a local diffuser for different real objects and surfaces.
The instrument to be built will also be able to perform a comprehensive characterization of the beam in terms of divergence, astigmatism, and M2.
The proposed method allows determining the maximum range of various rangefinders and LiDAR configurations without the need for calibration, making it suitable for both the development and production of LiDAR systems. A successful realization of a new reliable instrument could be of

great importance due to the increasing use of LiDARs for autonomous driving and the foreseeable requirement of periodically evaluating the conformity of these instruments.

References
[CI] - https://www.ci-systems.com/laser-range-finder-and-designator,
[Dio] - https://www.dioptic.de/en/portfolio/test-system-lidar/
[HGH] - https://hgh-infrared-usa.com/ircol-600-6000/
[EP06] - Joseph W. Ruhl, Jr.Arnold E. Glick, patent number EP0601872A1 / CA2111068A1 Laser rangefinder testing system incorporating range simulation, 1992
[Shi] - I-Fu Shih, patent number US5281813A "Laser rangefinder test system", 1994
[Erb] - V. Erbert and L. O. Braun, patent number US4068952,"Range testing system having simulated optical targets,",1978.
[Pat20] - N.F.Cunh, J.V. Gomes F.A.P. Oliveira, a patent number PCT/IB2021/056370 ,System to determine the maximum range of a LiDAR sensor - in submission (19 January 2023)
[Mac1] - Edward P. MacKerrow and Mark J. Schmitt, Measurement of integrated speckle statistics for CO2 lidar returns from a moving, nonuniform, hard target, Applied Optics, 1997
[Mac2] - Edward P. MacKerrow, Mark J. Schmitt, and David C. Thompson, Effect of speckle on lidar pulse–pair ratio statistics. Applied Optics,1997
[ISO] - ISO 11146-1:2005 Lasers and Laser-Related Equipment—Test Methods for Laser Beam Widths, Divergence Angles and Beam Propagation Ratios—Part 1-3, Geneva, Switzerland: ISO Standards, 2005.
[IEC] - IEC 60825-1:2014 -Safety of laser products –Part 1: Equipment classification, requirements and user's guide, 2014.
[McM] - Paul McManamon, Field Guide to Lidar, SPIE.Digital Libary, 2015
[Fan] - Xu.Fana,Wang. Jiaxingb, Zhu. Daiyina, Tu.Qic, Speckle noise reduction technique for Lidar echo signal based on self-adaptive pulse-matching independent component analysis, Optics and Lasers in Engineering 103 (2018) 92–99.
[Woj] - J. Wojtanowski, M. Zygmunt, M. Kaszczuk, Z. Mierczyk, and M. Muzal, "Comparison of 905nm and 1550nm semiconductor laser rangefinders'perfomance deterioration due to adverse environmental conditions,"Opto-Electronics Rev., vol. 18, no. 2, pp. 121–136, 2010.

Which topic best fits your talk?:

Optics and Photonics

High Energy Physics & Cosmology II (Chair: Carlos Herdeiro, Universidade de Aveiro) - Sala Sousa Pinto, DM (11.2.6) / 126

Searching for dark matter with the ATLAS detector using unconventional signatures

Author: Maura Barros[1]

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

Corresponding Author: maura.barros@cern.ch

The Standard Model (SM) can be considered an effective low-energy expression of a more fundamental theory.
Several observed phenomena cannot be explained by the SM, the existence of dark matter (DM) being one of them.
At the Large Hadron Collider (LHC), protons can stay intact after the interaction and be scattered by very small angles, which are then detected by the ATLAS Forward Proton tagging detectors (AFP), effectively converting the LHC into a photon-photon collider.
The search for DM can be done by targeting signatures in which pairs of soft leptons plus missing mass are produced in association with scattered protons tagged using AFP.
A model-independent search using this lepton+X signature is being conducted.

Which topic best fits your talk?:

High Energy Physics and Cosmology

Nanomaterials, Optics & Photonics (Chair: Ariel Gurreiro, Universidade do Porto) - Anf. Física (13.1.19) / 134

Color centers in diamond for neuronal signaling studies - 2 years in

Author: João Silva[1]

Co-authors: Orlando Cunha [2]; Filipe Camarneiro [3]; Beatriz N. L. Costa [2]; Paulo V. S. Marques [4]; Jana B. Nieder [2]

[1] *INL - International Iberian Nanotechnology Laboratory, Ultrafast Bio- and Nanophotonics group, Av. Mestre José Veiga s/n, Braga, Portugal; Department of Physics and Astronomy, Faculty of Sciences, University of Porto, Rua Campo Alegre 687, Porto, Portugal; INESC TEC, CAP –Centre for Applied Photonics, Rua do Campo Alegre 687, Porto, Portugal*

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

[3] *1INL - International Iberian Nanotechnology Laboratory, Ultrafast Bio- and Nanophotonics group, Av. Mestre José Veiga s/n, Braga, Portugal*

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

Corresponding Authors: jpcsjoaopaulo@gmail.com, jana.nieder@inl.int, orlando.cunha@inl.int, filipe.camarneiro@inl.int, psmarque@fc.up.pt, beatriz.costa@inl.int

This presentation summarizes the advances made in the first two years of my PhD fellowship program. Significant progress has been achieved in the area of laser-writing of nitrogen-vacancy (NV) centers, characterization of fluorescence microscopy and developing of ODMR systems and protocols for optimized sensitivity.
Advancements were made in the laser writing of NV center ensembles in diamond, utilizing a Satsuma HP laser for the writing process. Fluorescence intensity and spectroscopic data confirmed the fabrication of NV centers. However, Hanbury-Brown-Twiss (HBT) interferometry experiments were not able to prove single nitrogen centers.
Furthermore, an ODMR system was integrated in a widefield-TIRF microscope. An advanced ODMR method was successfully implemented with improved sensitivity. Additionally, 5V, 1ms biomimicking pulses magnetic field was measured by continuous-wave ODMR, serving as a proof of concept for neuronal action potential sensing.

Which topic best fits your talk?:

Optics and Photonics

High Energy Physics & Cosmology II (Chair: Carlos Herdeiro, Universidade de Aveiro) - Sala Sousa Pinto, DM (11.2.6) / 136

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. Preliminary results show at least 6 orders of magnitude increase in efficiency over random sampling.

Which topic best fits your talk?:

High Energy Physics and Cosmology

High Energy Physics & Cosmology III (Chair: Carlos Herdeiro, Universidade de Aveiro) - Sala Sousa Pinto, DM (11.2.6) / 113

Self-interactions can (also) destabilize bosonic stars

Author: Marco Brito[1]

Co-authors: Carlos Herdeiro ; Nicolas Sanchis-Gual ; Etevaldo Costa ; Miguel Zilhão

[1] *Universidade de Aveiro*

Corresponding Authors: herdeiro@ua.pt, etevaldocostaf@gmail.com, mzilhao@ua.pt, marcobrito@ua.pt, nicolas.sanchis@uv.es

We study the dynamical stability of Proca-Higgs stars, in spherical symmetry. These are solutions of the Einstein-Proca-Higgs model, which features a Higgs-like field coupled to a Proca field, both of which minimally coupled to the gravitational field. The corresponding stars can be regarded as Proca stars with self-interactions, while avoiding the hyperbolicity issues of self-interacting Einstein-Proca models. We report that these configurations are stable near the Proca limit in the candidate stable branches, but exhibit instabilities in certain parts of the parameter space, even in the candidate stable branches, regaining their stability for very strong self-interactions. This shows that for these models, unlike various examples of scalar boson stars, self-interactions can deteriorate, rather than improve, the dynamical robustness of bosonic stars.

Which topic best fits your talk?:

Astrophysics

Climate and Environment (Chair: Alfredo Rocha, Universidade do Aveiro) - Anf. Física (13.1.19) / 128

Testing the performance of six PBL Parameterizations under six Weather Types in Portugal

Author: Joana Martins[None]

Co-authors: Alfredo Rocha ; David Carvalho ; Susana Cardoso Pereira

Corresponding Authors: susana.cardoso@ua.pt, joanabasiliomartins@ua.pt, alfredo.rocha@ua.pt, david.carvalho@ua.pt

This study evaluates the performance of the Weather Research and Forecasting (WRF) model in simulating temperature, wind speed, and precipitation across six Weather Types (WTs) in Portugal. We compare six Planetary Boundary Layer (PBL) parameterizations, using observational data from IPMA for validation. Key metrics—Root Mean Square Error (RMSE), Bias, and Standard Deviation of Errors (STDE)—are calculated for each WT and PBL scheme.

Our findings highlight the significant impact of PBL choices on simulation accuracy, particularly for wind and precipitation, providing insights for improving regional climate modeling and weather forecasting applications.

Which topic best fits your talk?:

Climate and Environment

High Energy Physics & Cosmology III (Chair: Carlos Herdeiro, Universidade de Aveiro) - Sala Sousa Pinto, DM (11.2.6) / 117

THE NON-SPHERICAL GROUND STATE OF PROCA STARS

Authors: Etevaldo dos Santos Costa Filho[1]; Carlos Herdeiro[None]; Eugen Radu[1]; Nicolas Sanchis-Gual[None]; Nuno Santos[2]

[1] *Universidade de Aveiro*

[2] *CENTRA*

Corresponding Authors: nicolas.sanchis@uv.es, nunomoreirasantos@tecnico.ulisboa.pt, eugen.radu@ua.pt, herdeiro@ua.pt, etevaldo.s.costa@ua.pt

Spherical Proca Stars (PSs) are regarded as the ground state amongst the family of PSs. In accordance, spherical PSs are thought to have a fundamental branch of stable solutions.We provide energetic, morphological and dynamical evidence that spherical PSs are actually excited states. The ground state is shown to be a family of static, non-spherical, in fact prolate, PSs. The spherical stars in the fundamental branch, albeit stable against spherical perturbations, turn out to succumb to non-spherical dynamics, undergoing an isometry breaking into prolate PSs. We also provide evidence for the dynamical formation of prolate PSs, starting from spherical dilute initial data, via gravitational cooling. Consequently, PSs provide a remarkable example of (possibly compact) relativistic stars, in General Relativity minimally coupled to a simple, physical, field theory model, where staticity plus stability implies non-sphericity.

Which topic best fits your talk?:

Astrophysics

Climate and Environment (Chair: Alfredo Rocha, Universidade do Aveiro) - Anf. Física (13.1.19) / 130

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

Author: Ricardo Vaz[None]

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

[1] *CESAM - Universidade de Aveiro*

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

Extreme fire events have been increasingly frequent under changing Climate. Improving landscape resilience is key in reducing the ecological and socio-economic impacts of wildfires. This work aims to provide groundwork to incorporate future climate compatible land management scenarios with fire spread modelling tools. In this scope, the coupled fire-atmosphere modelling system WRF-SFIRE was used in combination with bioclimatic analysis to produce alternative landcovers, examining fire hazard. The Fire Weather Index (FWI) was chosen as a fire predictor to determine two distinct extreme fire weather events, Hot and Dry, Cool and Windy. Alternative landcovers, incorporating management and replacement of present cover, were cross-walked into fire behaviour fuel models, and assimilated by WRF-SFIRE. Each landcover was tested against both fire-weather events, providing insights on simulated fire intensity and spread. Results showed that agricultural areas can hamper progression in higher moisture wildfires. Fuel treatment of forested areas provided the greatest reduction of wildfire spread rates and intensity when compared to other management strategies, namely in lower wind speed regimes.

Which topic best fits your talk?:

Climate and Environment

High Energy Physics & Cosmology III (Chair: Carlos Herdeiro, Universidade de Aveiro) - Sala Sousa Pinto, DM (11.2.6) / 123

The Born regime of gravitational amplitudes

Authors: Giulia Isabella[1]; Miguel Correia[2]

[1] *University of California Los Angeles*

[2] *McGill University*

Corresponding Authors: giuliaisabella@physics.ucla.edu, miguel.ribeirocorreia@mcgill.ca, up202213096@edu.fc.up.pt

We study the 2⟶2 scattering in the regime where the wavelength of the scattered objects is comparable to their distance but is much larger than any Compton wavelength in the quantum field theory. We observe that in this regime - which differs from the eikonal - the Feynman diagram expansion takes the form of a geometric series, akin to the Born series of quantum mechanics. Conversely, we can define the Feynman diagram expansion as the Born series of a relativistic effective-one-body (EOB) Schrödinger equation. For a gravitational theory in this regime we observe that the EOB Schrödinger equation reduces to the Regge-Wheeler or Teukolsky wave equations. We make use of this understanding to study the tree-level Compton scattering off a Kerr black hole. We compute the scalar and photon Compton amplitude up to O(a30) in the black hole spin a and propose an all-order expression. Remarkably, we find that boundary terms, which are typically neglected, give non-zero contact pieces necessary for restoring crossing symmetry and gauge invariance of the Kerr-Compton amplitude.

Which topic best fits your talk?:

High Energy Physics and Cosmology

Climate and Environment (Chair: Alfredo Rocha, Universidade do Aveiro) - Anf. Física (13.1.19) / 131

Impact of dry deposition on WRF-Chem model results and size-resolved AOD during dust event over the Iberian Peninsula

Author: Rui Silva[1]

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

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

Atmospheric aerosols are known to significantly influence global and regional climates through their interactions with radiation and cloud microphysical processes. However, these interactions are difficult to represent in the current atmospheric chemistry models, because of their dependence on aerosol chemical composition, concentration, and size, which are intrinsically linked to aerosol emission, ageing, and removal processes.

In the absence of precipitation, large uncertainties arise from the parameterization of aerosol deposition across the aerosols'size spectrum. Hence, an incorrect representation of aerosol dry deposition could lead to inaccuracies in the estimation of aerosol optical properties and aerosol-radiation-cloud interactions

In this study, a large-scale configuration of the Weather Research and Forecasting model coupled with chemistry (WRF-Chem) is validated and used to evaluate the impact of three different aerosol dry deposition parameterizations coupled with the 8-size bin Model for Simulating Aerosol Interactions and Chemistry (MOSAIC 8-bin) on modelled aerosol concentrations, size distribution, and size-resolved aerosol optical depth during a Saharan dust event that affected the Iberian Peninsula during 8–12 of August 2010. Model results were evaluated against observations from meteorological, air quality, and sounding stations, as well as different satellite and ground based remote sensing measurements.

By performing model simulations using the different dry deposition options, it was found that the simulated aerosol loads across the different aerosol sizes are largely dependent on the of the dry deposition parametrization, especially for the particle size range 5.0–10 μm of the MOSAIC 8-bin, where domain-averaged relative differences in aerosol loads between simulations can be as high as 90 % and in aerosol optical depth at 550 nm (AOD) as high as 108 %. However, due to the compensating effects of aerosol mass in the smaller sized bins and the higher optical efficiency by unit of mass of the smaller aerosols, the domain-averaged relative differences on the size-integrated AOD do not exceed 30 % between the schemes.

These results highlight the importance of assessing the model's sensitivity to dry deposition for studies of aerosol feedback mechanisms.

Which topic best fits your talk?:

Climate and Environment

High Energy Physics & Cosmology III (Chair: Carlos Herdeiro, Universidade de Aveiro) - Sala Sousa Pinto, DM (11.2.6) / 137

NRSurNN3dq4: A Deep Learning Powered Numerical Relativity Surrogate for Binary Black Hole Waveforms

Author: Osvaldo Freitas[1]

[1] *University of Minho*

Corresponding Author: ogf1996@gmail.com

Gravitational wave approximants are extremely useful tools in gravitational wave astronomy. By skipping the full evolution of numerical relativity waveforms, their usage allows for dense coverage

of the parameter space of binary black hole (BBH) mergers for purposes of parameter inference, or, more generally, match filtering tasks. However, these benefits come at a slight cost to accuracy when compared to numerical relativity waveforms, depending on the approach. One way to minimize this is by constructing so-called *surrogate models* which, instead of using approximate physics or phenomenological formulae, rather interpolate within the space of numerical relativity waveforms. We have thus developed NRSurNN3dq4, a surrogate model for non-precessing BBH merger waveforms powered by neural networks. This approximant is extremely fast and competitively accurate: it can generate to the order of tens of thousands of waveforms in a tenth of a second, and mismatches with numerical relativity waveforms are restrained below 10^{-3}. We implement this approximant within the `bilby` framework for gravitational wave parameter inference, and show that it obtains good performance for parameter estimation tasks.

Which topic best fits your talk?:

Astrophysics

High Energy Physics & Cosmology III (Chair: Carlos Herdeiro, Universidade de Aveiro) - Sala Sousa Pinto, DM (11.2.6) / 138

TBounce: gravitational wave computations for primordial phase transitions

Author: Marco Marco Finetti[1]

[1] *Aveiro University*

Corresponding Author: mfinetti@ua.pt

The baryon asymmetry problem remains a crucial challenge in particle physics and cosmology. Electroweak baryogenesis, a leading mechanisms to produce the matter-antimatter asymmetry we observe today, requires an extension to the Standard Model to achieve a sufficiently strong first order phase transition.
Besides representing a target for several future-generation colliders, such Beyond the Standard Model (BSM) theories carry the potential to generate - through a thermal phase transition - gravitational waves (GWs) detectable by future space-based detectors, including LISA.
Despite growing interest in the problem, publicly available code to study different BSM scenarios is limited, the prevalent one being CosmoTransitions.
This presentation introduces a fully Mathematica-based paclet to fill the gap, offering a user-friendly and fully-automated tool to derive phase transition and gravitational wave parameters. The paclet exploits the recently developed FindBounce to compute the Euclidean tunnelling action.
Key features include
• simple phase tracing (in progress)
• identification of first order phase transitions
• computation of phase transition parameters (nucleation and percolation temperatures, strength, duration, $\cdots$)
• derivation of GW spectra from semi-analytical functions found in the literature
Although designed to work with any given thermal potential, the paclet is intended to interface smoothly with DRalgo, a Mathematica package for dimensional reduction and thermal effective field theory computations.
Currently under development, the tool is being tested on a variety of single-field models, including the abelian Higgs, a coupled fluid-field, and a dark photon model.
This presentation will cover preliminary results and future development plans, showcasing the potential for this new paclet to become an invaluable resource in the field of cosmological phase transitions.

Which topic best fits your talk?:

High Energy Physics and Cosmology