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Abstract Book

Departamento de Física
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Contents

Abstracts

Rad-Path Correlation of Deep Learning Models for Prostate Cancer Detection

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Engenharia Biomédica e Biofísica

While Deep Learning (DL) models trained on Magnetic Resonance Imaging (MRI) have shown promise for prostate cancer detection, their lack of direct biological validation often hinders clinical adoption. Radiologic-histopathologic (rad-path) correlation has the potential to validate MRI-based lesion detection using digital histopathology. We used automated and manually annotated digital histopathology slides as a standard of reference to evaluate the spatial extent of lesion annotations derived from both radiologist interpretations and DL models previously trained on prostate bi-parametric MRI (bp-MRI). Prospective patients with clinically significant prostate cancer underwent a bp-MRI examination before undergoing a robotic radical prostatectomy, and each prostate specimen was sliced using a 3D-printed patient-specific mold. We trained DL models for cancer detection on large retrospective datasets of T2-w MRI only, bp-MRI and histopathology images, did inference in a prospective patient cohort, and evaluated the spatial extent between detected lesions and between detected lesions and the ground-truth.

Development of a urinalysis biochip system for continuous monitoring of health parameters integrated into a sanitary device.

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Continuous monitoring of biomolecules in urine can reveal early signs of disease, when treatment is most effective and cost-efficient. However, current health monitoring is often invasive and dependent on clinical visits. My PhD addresses this challenge by developing a multiplex biosensor based on extended-gate field-effect transistor (FET) technology, seamlessly integrated into a smart toilet to enable effortless, frequent, and non-invasive biomarker analysis. So far, the biosensor system has been tested for pH and creatinine detection. For pH, the BioFET showed a sensitivity of 2.20 μA/pH and a limit-of-detection (LOD) of 0.83. For creatinine, the system demonstrated a strong linear response (96%) achieving a sensitivity of 0.097 μA/μmol L^{-1} and a LOD of 46 μmol L^{-1}. The next steps include expanding the number of biomarkers and validating the system with urine samples, bringing us closer to a future where a simple toilet can support early diagnosis and improve patient outcomes.

Retrospective modeling of school-related COVID-19 transmission in the Netherlands and Portugal

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Understanding the contribution of schools to COVID-19 transmission has been a major challenge in shaping effective and balanced public health policies. We present findings from two retrospective modeling studies conducted in the Netherlands and Portugal, focusing on school-related interventions during the pandemic. Using age-stratified transmission models, we assess the impact of closures, reopenings, and mitigation strategies on infection and hospitalization dynamics. Our results highlight how the role of schools evolved over time, differing across educational levels and national contexts. These studies provide evidence to support more targeted and proportionate school-based policies, offering valuable lessons for future pandemic preparedness and response planning.

NIBS techniques targeting Schizophrenia

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Schizophrenia is a complex psychiatric disorder that can be understood, from the point of view of the cortical hierarchy theory, as a dysconnectivity disease, which is a concept developed by Friston´s work. Altered oscillatory patterns, such as the reduction of sleep spindles during NREM sleep, and alterations in cortical responses, specifically the N1 and P3, are found in schizophrenia. This project has three main objectives. 1) It aims to develop a thalamocortical neural mass model that describes the altered oscillatory patterns observed on the EEG during NREM sleep in the schizophrenic population. 2) Transitioning the model for awakening and simulating the altered N1 and P3 responses. 3) Once the model is complete, we will explore the benefits of different NIBS approaches, based on relevant previous works, aiming to assess the value of these therapeutic modalities targeting such alterations. It will allow for translational clinical studies in the future.

A Preliminary Study on the Impact of Model Complexity in Classification in Breast Microwave Imaging

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This study investigates the capability of microwave signals to classify benign and malignant breast tumours. The novelty of this study lies in the anatomically and dielectrically accurate breast tissue models - including tumours - used in the simulations, in multiple scenarios with different tissue types (fat, fibroglandular, skin, and muscle) and varying heterogeneity. Principal Components Analysis (PCA) was applied as a Feature Extraction Method (FEM), and Support Vector Machines (SVM) for the classification. Key metrics including accuracy, sensitivity, specificity, F1 score, and Matthews Correlation Coefficient (MCC), assessed each antenna's diagnostic capability and the combined performance across all antennas. Results suggested that combining classifications from all antennas via majority voting improved accuracy, while tumour classification was unaffected by tissue heterogeneity. Increasing model complexity did not impact SVM performance except when muscle tissue was added, slightly reducing the diagnostic performance.

Development of Microdosimetric Detectors for Radiobiology in Hadron Therapy Facilities

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Sapphires, long treasured for their beauty, hold a secret superpower: the ability to detect radiation. By altering their composition, these precious stones become highly sensitive personal dosimeters. But this is just the beginning. Our work is focused on the development of sapphire-based passive dosimeters for microdosimetry and radiobiology, aiming to map exactly how radiation damages cells and DNA. These crystals store the tracks of individual particles, that can be correlated to the type and aggressiveness of cell damage. This information helps us to improve radiotherapy treatments and prevent the harmful effects of radiation. The challenge? Growing sapphires that can detect every kind of radiation. By demystifying the crystal-growth process, we are transforming a precious gem into a futuristic tool, proving that sometimes, the key to innovation is hiding in plain sight... perhaps even on your finger.

Experimental realization of stochastic folding

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Self-folding kirigami lets us turn flat templates into 3D shapes. At the macroscale, this usually follows a single, predictable path. But at the microscale—like in DNA origami or folding droplets—tthe process is stochastic due to thermal noise. Despite this, it makes the folding process simpler, reversible, and easier to scale up. Most work so far has been simulations, since controlled microscale experiments are tough. We propose a macroscale setup that uses random interactions to mimic those small-scale systems. By comparing our results with microscale data and simulations, we hope to better understand how complex structures come together.

Exploring and Understanding the Primordial Universe

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What shaped the universe in its first fraction of a second? In this brief talk, we'll explore the primordial universe, an era that was the seed for what we observe today. We'll discuss the mystery of why matter dominates over antimatter, and how this imbalance may have originated. We'll also look at exotic possibilities like primordial black holes, hypothetical relics from the early cosmos, and what they could reveal about dark matter. Finally, we'll touch on primordial gravitational waves: faint echoes from the very beginning that might soon be within our reach. This journey into deep time combines cosmology, quantum theory, and astrophysical clues to help us understand not just how the universe began, but why it looks the way it does.

A complete characterisation of Ultra Steep Spectrum radio sources in the COSMOS field

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Ultra Steep Spectrum (USS) radio sources have been successfully used to select powerful radio galaxies at high redshifts ($z > 2$). General understanding is that this radio excess emission is due to an Active Galactic Nuclei (AGNs). Radio samples drawn from previous generation of large-sky surveys typically unveil relatively bright sources (those with the largest radio flux densities), and the USS criteria has been successfully used to select high redshift sources in this regime. However, with the advent of a new generation of radio surveys produced by Square Kilometre Array (SKA) pathfinders, it has become possible to extend the USS selection to lower sensitivity levels. We aim to investigate if the efficacy of the USS criterion in radio samples drawn from deep radio observations remains effective for selecting high-redshift galaxies in the sub-mJy regime using these new observations. Additionally, we want to investigate the nature of the USS sources identified in our sample. Combining recent observations from the MeerKAT International Gigahertz Tiered Extragalactic Explorations (MIGHTEE) at 1.22 GHz (24 cm) and Very Large Array (VLA) at 3 GHz (10 cm) toward the two square degree Cosmic Evolution Survey (COSMOS) field, usually called VLA-COSMOS, the majority of which also have optical/near-infrared measurements and redshift (spectroscopic and photometric) estimates. Using comprehensive multi-wavelength dataset available over this field, we are able to extensively characterise this population, investigate the efficiency of the USS radio criteria to reach the highest redshifts at the faintest radio fluxes, of high relevance to the preparation of future SKA surveys. We identify ~ 500 USSs and the population does not show significant differences from the broader sub-mJy radio population, in particular revealing a large number of star-forming galaxies

with a redshift distribution peaking at z < 1. This work probes the effectiveness of the USS criteria down to faint flux levels and suggests that an additional criteria can be explored for a refined selection of distant radio galaxies, in particular in the upcoming SKA-era.

Active Volcanism and the lost Oceans of Venus

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Thousands of volcanoes dominate the landscape of our neighbouring planet Venus. Until recently, the activity status of some of these volcanoes was uncertain. Using radar data from the NASA's Magellan mission to Venus, we present evidence of ongoing volcanism on the planet. We combine a variety of astronomical observations, remote sensing data, and numerical modelling to reshape the volcanic narrative about Venus. We also explore the planet's distant past when surface conditions may have been more amenable. We use the NASA/ROCKE-3D General Circulation Model to study Ocean circulation on the paleo-Venus as a representation of a slow-rotating planet. We discuss the crucial role of ocean currents and tides in energy redistribution and their potential implications for Habitability.

Open cluster dissolution: modelling their age and mass distributions

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Most stars form in clusters that eventually disperse, making open cluster (OC) dissolution key to galactic evolution. We analysed 1724 OCs using Gaia DR3, deriving limiting radii and luminous masses, and modelled their disruption. Using the widely adopted power-law Initial Cluster Mass Function (ICMF) our model was able to reproduce the observed age distribution, but it failed to match the mass distribution. We explored alternative ICMFs and found that using a skew log-normal distribution provides a good match to the observations. We also found a disruption timescale of 2.0 Gyr (for a cluster with initial mass of 10.000 solar masses) and indications that bound OCs emerge with a different mass distribution than embedded clusters. Our results imply mass-dependent cluster disruption during the emergence from their parent clouds, and reveal a possible lower mass limit of around 60 solar masses for bound OCs in the solar neighbourhood.

Development of an artificial intelligence-based assisted navigation and monitoring solution for pulmonary point-of-care ultrasound

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Physicians can use point-of-care ultrasound (POCUS) to quickly monitor pulmonary infections. The operational complexity of POCUS, which requires expert knowledge and training to be effective, limits its widespread use. What if we could automatically guide an inexperienced user in positioning a POCUS probe for image analysis and provide him with a severity score suggestion? This project will focus on developing that kind of solution. Deep learning algorithms will be developed to aid in the ultrasound probe's navigation and positioning, as well as to perform an automatic diagnosis. The developed solution will be tested with our partner Hospital Garcia de Orta (HGO). This technology can speed up and reduce the cost of monitoring pulmonary infections. Critical social impact is also expected, due to the applicability of this project to remote places lacking access to hospitals and specialists, unfavourable social-economic contexts, and crises like pandemics.

Self-Supervised Learning for Prostate Cancer Detection in Pre-Biopsy MRI

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Prostate cancer (PCa) is the most commonly diagnosed malignancy among European men and ranks third in cancer-related mortality. While the current diagnostic pathway—which includes initial screening, MRI evaluation, and biopsy—effectively identifies clinically significant cases, it often leads to overdiagnosis and unnecessary treatment of benign or indolent tumors. This project seeks to develop innovative, AI-driven methods to improve detection accuracy and risk stratification based on pre-biopsy MRI scans. Although existing AI models have shown potential, they have yet to demonstrate clear benefits over standard clinical workflows. A key limitation is the lack of high-quality, expert-annotated data to serve as definitive ground truth. To overcome this, we will investigate data-driven approaches—such as self-supervised learning—that utilize large collections of unlabeled MRI scans for model pretraining, enabling effective fine-tuning on critical diagnostic tasks with substantially fewer labeled examples.

Cancer weapons against neurodegeneration

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Neurodegenerative disorders (NDs) are characterized by misfolded amyloid accumulation and neuroinflammation, leading to cellular death. Low-dose radiation therapy has shown promise in treating amyloid-related conditions such as peripheral amyloidosis, which shares pathological features with NDs. Recent strategies involve boron-based compounds to enhance the effectiveness of radiation therapy, namely Proton Boron Capture Therapy (PBCT). This project investigates whether combining boron compounds with low-dose proton radiation can reduce amyloid aggregation and neuroinflammation. Simulations were performed using TOPAS-nBio with the PDB4DNA extension, adapted for protein structures, to evaluate radiation-induced bond breakage in amyloid proteins. Additional simulations of proton-boron interactions were conducted to evaluate dose enhancement. Results revealed that proton irradiation generates more bond breaks than conventional radiation therapies. Although the proton-11B reaction did not significantly enhance dose deposition due to its low cross-section, it markedly increased alpha particle production, suggesting potential biological relevance for therapeutic applications.

Atmospheric Gravity Waves on Mars: Morphology and Dynamics from HRSC/MEx imagery

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Atmospheric gravity waves are disturbances driven by buoyancy when air is vertically displaced, producing ripple-like motions that transport energy and momentum through the atmosphere. On Mars, they play a key role in shaping winds, redistributing heat, and forming high-altitude clouds, with strong temporal, seasonal, and latitudinal variability.

My PhD research focuses on detecting and characterising these waves using imagery from space-based instruments such as OMEGA and HRSC onboard Mars Express. I analyse their morphology, propagation speed, and vertical structure across different latitudes, local times, and seasons, to understand how wave activity evolves in space and time.

By combining image analysis with atmospheric modelling, I investigate how gravity waves interact with large-scale circulation and what they reveal about Martian climate dynamics. Building on previous studies in the Venusian atmosphere, this work extends the methodology to Mars, providing new observational constraints to improve climate models and guide future atmospheric missions.

Phase transitions in extensions of the Standard Model

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The theoretical task of predicting the gravitational wave spectrum from a first order electroweak phase transition can be divided into two main parts, the first of which concerns the calculation of the phase transition parameters from the effective potential. The higher-order, temperature-dependent calculation is fraught with technical difficulties which lead to large theoretical uncertainties. One aspect that has been less explored in the literature is renormalisation scheme dependence. We want to investigate the overall renormalisation scheme dependence of the one-loop, temperature-dependent effective potential and its impact on gravitational wave observables.

Microwave Imaging for Breast Cancer Screening and Axillary Lymph Node Detection

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Breast cancer (BC) is the second most prevalent cancer worldwide. Medical Microwave Imaging (MMWI) is an innovative approach that has been applied to BC screening, with multiple systems proposed that underwent clinical trials with promising results. Cancer cells from the breast first metastasise to the axillary lymph nodes (ALNs), being important to assess these for BC staging. In our research group, we have developed a first-generation MMWI prototype to screen the breast and the axilla at the same time. We are developing our second-generation prototype for BC screening and ALN detection. So far, no study in the literature has investigated the ideal frequency band to image the axillary region. Therefore, we have modelled the axilla as transmission lines considering common and extreme anatomical variations. We solved the transmission lines analytically and determined the optimal frequency band. The found frequency band was validated with full-wave simulations in anthropomorphic models.

The Birth of the Galaxy Main Sequence in the Young Universe

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Galaxy evolution is an exciting topic of Astrophysics, which we still do not fully understand. One of the most fundamental correlations found so far links the rate of stars formed by a galaxy and its mass. This correlation, called 'main sequence' (MS), has been strongly constrained statistically only in the nearby Universe, where current instruments can observe millions of galaxies in a reasonable amount of time. This introduced large uncertainties at higher distances, and it is still not clear if and how the MS evolves. This project will tackle this problem by analysing data from MOONS, a revolutionary instrument to be installed at the VLT next year. The participation of Portugal in the construction of the instrument and its privileged access to the data will allow tackling this scientific problem from an advantageous position, covering the ages when the MS was settling and galaxy assembly was in place.

PoET: The Paranal solar ESPRESSO Telescope

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The discovery and characterization of exoplanets like Earth is being obstructed by stellar "noise". The detection and characterization of low-mass planets is severely challenged by the various physical processes of the host star which modify stellar spectra. A detailed study of Sun can be used as a spectral proxy to a better understanding of the variable noise sources present in solar-type stars. To tackle this problem, the Institute of Astrophysics and Space Sciences in Portugal is currently developing an instrument, Paranal solar ESPRESSO Telescope (PoET), to be installed at ESO's Paranal observatory in Chile, to operate in conjunction with the high-resolution spectrograph ESPRESSO. PoET has the requirement to perform simultaneous observations: disk-resolved, from 1 to 55 arcsecond, and disk-integrated, capturing the full disk of the Sun. In this presentation the current configuration for PoET will be showcased, as well as the current state of the instrument.

Modeling the Radiobiological Effects of Gold Nanoparticles in Proton Therapy of Glioblastomas

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Glioblastoma multiforme (GBM) is an aggressive stage IV brain tumor with a median survival of only 15 months and a 5-year survival rate below 6%. Its strong resistance to radiation makes improving radiosensitivity crucial. A promising strategy is enriching tumors with high-Z nanoparticles such as gold nanoparticles (AuNPs), which amplify radiation effects in cancer cells without increasing dose to healthy tissue. Under irradiation, AuNPs enhance electron emission and reactive oxygen species production, leading to stronger DNA damage. To disentangle these effects, we developed Monte Carlo simulations using detailed 3D cell geometries reconstructed from confocal microscopy images. Cells were irradiated with different radiation types, and both DNA damage and survival fractions were analyzed. Strikingly, the simulations reproduced trends observed in experiments, confirming the potential of this approach. This work provides powerful tools to explore how nanoparticles can transform radiotherapy for resistant tumors like GBM.

Jovian upper clouds and hazes from visible and near infrared spectroscopy using CARMENES

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The aerosol scheme of Jupiter's upper hazes and clouds is still not properly understood. I used unique observations with CARMENES from 2019, from VIS to NIR, to test three competing schemes. The observations were grouped into 5 distinct regions and a Minnaert limb-darkening approximation was performed. From the analysis, across all three models, the properties of the highest located aerosols have the most influence in the retrievals, and the extended chromophore scheme fits best the observations. However, none of the models fully represent what it is observed, indicating that better models that take into account observations from UV to mid-IR holistically are required to fully understand the hazes and clouds of Jupiter.

Measuring Isotopic Ratios on Venus' Dayside using iSHELL/IRTF Observations

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The measurement of isotopic ratios on Venus is crucial to track atmospheric loss though time, constrain planetary origin and trace surface-atmosphere interactions.

We present new simultaneous measurements of bulk-averaged ratios of $^{16}O/^{18}O$, $^{16}O/^{17}O$ and $^{12}C/^{113}C$, measured on CO2, on Venus' dayside, from high spectral resolution (R $\sim$ 80 000) iSHELL/IRTF observations, using the H3 mode (1.64-1.82 μm), performed on the 2nd February 2024. Venus angular diameter was 12.2", with an illuminated fraction of 86.1 %. Wavelength calibration, flat fielding, dark correction and sky subtraction were performed using the Spextool data reduction software.

The following preliminary weighted averaged isotopic ratios were computed: $^{16}O/^{18}O \sim 507 \pm 50$, $^{16}O/^{17}O \sim 2745 \pm 152$ and $^{12}C/^{13}C \sim 90 \pm 6$, which are consistent with previously reported values.

AI predicts Breast Cancer three years in advance

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Early detection is the most powerful tool we have against breast cancer, but current methods often miss the bigger picture. Now, advances in deep learning are opening a new frontier: predicting who is at risk years in advance, with greater precision.

Mapping the discrete folding landscape

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Folding is emerging as a promising manufacturing process to transform flat materials into functional structures, offering efficiency by reducing the need for welding, gluing, and molding, while minimizing waste and enabling automation. Designing target shapes requires not only to determine cuts and folds, but also folding pathways. Simple combinatorics is impractical as the possibilities grow factorially with the number of folds. To address this, we present a graph-based algorithm for polyhedral shapes. By representing the target shape as a graph, where nodes correspond to faces and edges represent adjacency, the algorithm identifies all possible fold sequences and maps the configuration space into a discrete set of intermediate configurations. This systematic mapping is critical for the design of optimized processes, the simplifying of folding operations, the reduction of failures, and the improvement of manufacturing reliability.

Can the electroweak phase transition produce gravitational waves?

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Yes — but only with new physics! The electroweak phase transition can generate gravitational waves, but only if the Standard Model is extended with additional scalar fields. Such extensions not only make the transition first-order, enabling gravitational wave production, but can also address major open questions like dark matter, neutrino masses, and the matter–antimatter asymmetry.

Study of Short Range Correlations in asymmetric nuclei at R3B

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Nucleon-nucleon short-range correlations (SRCs), are a universal feature in atomic nuclei. Previous studies using electron scattering have shown that protons are more likely to form SRCs in asymmetric nuclei as the neutron excess increases. However, such studies are constrained to stable nuclei with limited neutron excess and do not allow for a clear separation of the mass effect from the neutron excess. My PhD Thesis focuses on the preparation, execution and analysis of an inverse kinematics experiment with the R3B setup at GSI-FAIR. High-energy beams (E = 1.25 GeV/u) of the neutron-rich isotope 16C and the symmetric 12C impinge in a liquid hydrogen target, producing (p,2p) reactions. In this reactions single nucleons can be knocked out even when bound in an SRC pair, allowing for their study. This study sets the stage for future experiments at FAIR, enhancing our understanding of SRCs and their role in asymmetric nuclear matter.

Preliminary study of the mechanical properties of biological tissue during microwave hyperthermia

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Hyperthermia refers to heating tissue between 40 ^{o}C and 45 ^{o}C. In oncology, it is used as an adjuvant therapy to enhance the effects of radiotherapy and chemotherapy. Heat also induces conformational changes in proteins, which alter the tissue's stiffness. In this work, we measure the mechanical properties of ex vivo chicken breast samples during heating and simulate the effect of gravity and thermal deformation on tissue heated for 60 min. We compare these effects – in a smaller and larger region – to the reference state (the mechanical properties are constant, and there is no thermal deformation). We conclude that the displacement of the heated areas between the two states (reference and after 60 min of hyperthermia) is 0.70 mm and 6.45 mm for the geometry with smaller and larger heated regions, respectively. Future work should address the impact of blood flow on the temperature distribution of tissues treated with hyperthermia.

Gravitational wave propagation in modified gravity

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In this talk, I will provide a brief overview of gravitational wave propagation in a Minkowski space-time background within the framework of a modified gravity theory known as hybrid metric-Palatini gravity. In particular, I will present the formal aspects of the theory, followed by a discussion of the main results on the possible existing polarization modes, and then argue how we could distinguish such modes from those of General Relativity using current and future observations.

Development of pathomics model for prostate cancer stratification

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Prostate cancer (PCa) diagnosis and prognosis remain major clinical challenges. My PhD project aims to develop explainable deep learning (DL)-based pathomics models for PCa stratification, using digital pathology, MRI, and proteomics data. We are building an end-to-end pipeline to extract robust radiomics and texture features from high-resolution whole-slide pathology images, independent of the DL architecture, enabling accurate classification of tumor aggressiveness and recurrence risk.

Key innovations include intelligent down-sampling strategies, tile-based classification, and the integration of imaging with urinary proteomic biomarkers to enhance prediction and support biomarker discovery. This multidisciplinary project is strengthened by clinical, biological, and computational training through secondments in hospitals and research centers across Europe.

The expected outcome: validated tools for PCa risk stratification, a prototype integrative model for clinical use, and significant contributions to precision oncology through AI. Join me to explore how AI is transforming cancer diagnosis, one pixel at a time.

The true power of rainbows

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What if rainbows held the key to answering one of humanity's greatest questions — are we alone in the universe?

Astronomers employ high-resolution spectrographs (rainbow making machines) to analyse the light from distant stars, enabling the detection of exoplanets and characterization of their atmospheres.

However, ground-based observations are fundamentally limited by Earth's atmosphere, which attenuates and contaminates the incoming signal, especially in the near-UV and IR bands. The solution is clear: use high-resolution spectrographs above the atmosphere. Yet, conventional cross-dispersed echelle (CDES) spectrographs are large, complex, and bulky — often comparable in volume to a living room — making them incompatible with satellite platforms.

My research addresses this challenge through the miniaturisation and optimisation of CDES, balancing spectral resolution, throughput, and dimensions. The goal: to enable small satellite class instruments capable of high-resolution spectroscopy. A crucial step toward identifying an Earth like planet orbiting a Sun like star.

Exploration of Powerful Active Galactic Nuclei

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One of the fundamental questions in astronomy is how galaxies form and evolve through cosmic time. For the past few decades, various teams have tried to answer this question by constructing computational models for simulated galaxies and their associated active galactic nuclei (AGN).

More recently, efforts have been made to improve these models through the implementation of improved recipes for radio emission, in preparation for the upcoming Square Kilometre Array era. These recipes depend heavily on our understanding of AGN mechanics from observations of nearby galaxies, including the monitorization of their flux variability.

Over the past three years, under a collaborative agreement between the Institute of Astrophysics and Space Sciences and RAEGE-Az, we are looking to establish an AGN monitoring program using the radio telescope located in Santa Maria, Azores. Here we report the results of our observations, in preparation for the monitoring program.

Healing Regimes in the Vertex Model

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Wounds in epithelial tissues compromise their vital role in homeostasis. A rapid and efficient wound healing encompasses different mechanisms, which includes the formation of a contractile actin-myosin cable around its edge, known as the purse-string mechanism. We combine mean-field calculations and numerical simulations of the Vertex model to study the interplay between tissue properties and the purse-string mechanism and its impact on the healing process. We find different regimes, where the wound opens, closes partially or completely. We also derive an analytic expression for the closure time which is validated by numerical simulations.

The role of oxytocin in autistic traits: A pharmaco-genetic-neuroimaging study

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Autism spectrum disorders (ASD) have impaired social cognition processes, decreasing their ability to perceive social cues. Autistic traits (AT), present in the general population as a continuum, are associated with abnormal lower amygdalar reactivity during social stimuli visualization. ASD is also associated with a dysfunction of the oxytocin (OT) system. To characterize AT in terms of amygdala activity in response to social stimuli and how it is affected by inOT, in neurotypical individuals, we ran a double blind, placebo-controlled, between-subjects study design, administering participants with inOT or placebo, before presenting them with an emotion recognition task concurrently to fMRI data collection. Additionally, we used specified questionnaires for AT profiling. We expect that the AT score will show a negative correlation with amygdalar reactivity to emotional (vs. neutral) faces, as seen in ASD/AT, with it being counteracted by inOT, leading to increased amygdala responsivity towards normal levels, particularly in high-AT individuals.

From Icy Moons to Hot Exoplanets: Bayesian Retrievals on Atmospheric Spectra

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The age of big data has arrived for Planetary Astrophysics. With thousands of newly discovered exoplanets and state-of-the-art instruments on the ground and in space, it is critical to find fast and standardized ways to extract information from noisy and often-times degenerate observables present in spectra of planetary atmospheres, within and beyond our solar system. Over the course of my 1st year of PhD between FCUL - Instituto de Astrofísica e Ciências do Espaço and University College London, I have been exploring how Bayesian Retrievals allow to constraint atmospheric parameters on JWST observations of transiting exoplanets – and how distinct data reduction procedures may bias the retrieved characteristics of planetary atmospheres. I have also taken advantage of this technique, usually used for low-resolution spectroscopy of exoplanets, to detect a new photochemical species, C3, on the upper atmosphere of Titan, using original data from the Ultra-High-Resolution spectrograph VLT-ESPRESSO.

RelExt: A New Dark Matter Tool for the Exploration of Dark Matter Models

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RelExt is a C++ tool designed to study Standard Model extensions that include a Dark Matter candidate. It efficiently scans the parameter space of these models to find regions compatible with the observed relic density. The code computes the relic density for freeze-out and automatically includes all the co-annihilation processes. It supports several built-in models or any custom model with a discrete Z2 symmetry, requiring only the corresponding FeynRules files. It can be easily linked with external tools like ScannerS, to check for the relevant theoretical and experimental constraints, or BSMPT, to explore the phase history of the model and possibly related gravitational waves signals.

(Mo)defying gravity

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Gravity is not working as expected, at the largest scales of the observable universe. So, it's time to try defying gravity by modifying Einstein's theory.

Solute dispersion in confined active liquids

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Many active fluids contain distinct chemical species, and their spatial distribution can have significant implications. We investigate the dispersion of solutes in active nematic fluids confined to narrow channels using hydrodynamic simulations.

Under confinement, active nematic fluids spontaneously adopt periodic flow patterns. This study examines two regimes: (1) a flow along the channel with sinusoidal streamlines, and (2) a one-dimensional lattice of alternating vortices.

Non-diffusive tracers exhibit ballistic dispersion in the oscillatory flow, but perform a diffusive random walk from vortex to vortex in the dancing flow. In contrast, solutes driven by active flows show diffusive behavior in both regimes, which can be captured by an extension of classical channel dispersion theory.

These results contribute to our understanding of micromixing in active flows, both in natural settings and potential applications.

Caking as a percolation problem

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Caking in amorphous powders compromises their quality during storage. Individual particles absorb water vapor, which changes their viscosity and promotes the formation of sinter bridges. Lumps of particles grow and eventually span the whole powder, affecting the mechanical properties and quality of the powder. Previous studies of the caking dynamics largely neglect the role of spatial heterogeneities in the particle-size distribution. We perform particle-based simulations and show that, if caking is mapped into a percolation transition, the role of spatial heterogeneities is well captured by the corresponding percolation threshold.
