Third Cross-Collserola PhD Meeting in Astrophysics, Cosmology and Particles 2025

Report of Contributions

https://indico.icc.ub.edu/e/659

Contribution ID: **1** Type: **not specified**

Welcome!

Friday 10 October 2025 09:15 (15 minutes)

Time for informal talks and getting your accreditations! Also, put up your poster!

Contribution ID: **2** Type: **not specified**

Introduction :)

Friday 10 October 2025 09:30 (15 minutes)

Welcome talks from the SOC and institute director.

Contribution ID: **63** Type: **Poster**

Gravitational wave memory from primordial black hole mergers

Gravitational waves below the merger frequency carry two distinct signatures: the chirping inspiral and the non-linear memory. But which one will detectors capture first? We address this question in the context of light primordial black hole binaries, where mergers occur above the peak sensitivity of current instruments. Our analysis shows that detectors are far more sensitive to the inspiral than to the memory, once the binary evolution history is taken into account. We also examine memory waveforms for ground- and space-based interferometers, highlighting the implications for matched-filtering searches. This comparison reveals how next-generation high-frequency detectors, tuned to the merger, stack up against existing interferometers and where each has the advantage.

Author: GASPAROTTO, Silvia (IFAE)

Presenter: GASPAROTTO, Silvia (IFAE)

Contribution ID: **64** Type: **Talk**

Charizard to charmonium: the de-evolution of quarkonia through pion emission

Friday 10 October 2025 12:00 (9 minutes)

Have you ever wondered what Pokémon and particle physics have in common? I did. So let me take you along my journey to becoming a true Particle Master. Like any respectable Pokémon adventure, it all starts with choosing your first particle. Mine is charmonium (Charmander best gen 1 starter). Before sending it into battle, the most important thing is to understand its properties and behavior.
With the help of the Born–Oppenheimer Effective Field Theory, we can map out the energy levels and wavefunctions of these heavy quark states. But the real fun begins when we ask: how do they evolve, or sometimes de-evolve, by emitting pions? To model this, one could use the classic multipole expansion, but I've chosen a different path: the QCD string description. By building the right Lagrangian, we gain insight into pion scattering, quarkonium transitions, and maybe even unlock the way to finally get a Charizard (or at least a decent approximation of one).

Author: TOMÀS VALLS, Sandra (ICCUB)

Presenter: TOMÀS VALLS, Sandra (ICCUB)

Session Classification: Morning talks

Contribution ID: **65** Type: **Talk**

Quantum Transparency of Near-extremal Black Holes

Friday 10 October 2025 10:30 (9 minutes)

We investigate the scattering of electromagnetic and gravitational waves off a Reissner-Nordström black hole in the low-temperature regime where the near-horizon throat experiences large quantum fluctuations. We find that the black hole is transparent to electromagnetic and gravitational radiation of fixed helicity below a certain frequency threshold. This phenomenon arises because the angular momentum of the black hole is quantized, creating an energy gap between the spinless black hole state and the first excited spinning states. Radiation with angular momentum—such as photons, gravitons, and partial waves of a massless scalar field, which we also study—must supply enough energy to bridge this gap to be absorbed. Below this threshold, no absorption can occur, rendering the black hole transparent. For frequencies above the gap, the scarcity of black hole states continues to suppress the absorption cross-section relative to semiclassical predictions, making the black hole translucent rather than completely transparent. Notably, electromagnetic absorption is significantly stronger than gravitational absorption, beyond what differences in spin alone would suggest.

Authors: EMPARAN, Roberto (ICREA & Universitat de Barcelona); TREZZI, Stefano (Institute of Cosmos Sciences, University of Barcelona (ICCUB))

Presenter: TREZZI, Stefano (Institute of Cosmos Sciences, University of Barcelona (ICCUB))

Session Classification: Morning talks

Contribution ID: **66** Type: **Talk**

Dark energy reconstruction and crossing of the phantom divide

Friday 10 October 2025 13:03 (9 minutes)

Hints of dynamical dark energy (DE) have strengthened under the combination of data from CMB, SNIa and BAO from DESI. This evidence is typically quantified using the well-known CPL parameterization of the DE equation-of-state, $w_{\rm DE} = w_0 + w_a(1-a)$. However, this truncation may bias our interpretation of the data, potentially leading us to mistake spurious features of the best-fit CPL model for genuine physical properties of DE. We keep more terms in the expansion and apply the Weighted Function Regression (WFR) method to eliminate the subjectivity associated with the choice of truncation order. Using this model-agnostic approach we reconstruct cosmological functions and quantify that evidence for a crossing of the phantom divide is statistically significant, with confidence levels ranging from 96.21% to 99.97%, depending on the SNIa dataset. Finally, I will show that the effective DE fluid from a combination of standard and negative quintessence can produce the reconstructed shape of $w_{\rm DE}(z)$.

Author: GONZÁLEZ FUENTES, Alex

Presenter: GONZÁLEZ FUENTES, Alex

Session Classification: Morning talks

Contribution ID: **67** Type: **Talk**

Detectability of Neutron Star Resonance effects

Friday 10 October 2025 12:54 (9 minutes)

This talk shows our work studying the detectability of resonance effects in BNS and NSBH binaries. The resonant effects under study consist of the excitation of NS oscillatory modes due to the coupling of the modes with the tidal field exerted by the companion object during inspiral phase. Mode excitation occurs when the orbital frequency of the binary sweeps through the characteristic frequencies of the modes. Our goal is to model the contribution of the mode excitation to the GW waveform and study its detectability applying match-filtering techniques. We consider current (LVK: O4) and under design (LVK: O5, ET) detector noise curves.

Authors: REVILLA, Alberto (Institut de Ciències del Cosmos Universitat de Barcelona (ICCUB)); Prof. LUNDGREN, Andrew (IFAE); BONDARESCU, Ruxandra (Universitat de Barcelona)

Presenter: REVILLA, Alberto (Institut de Ciències del Cosmos Universitat de Barcelona (ICCUB))

Session Classification: Morning talks

Contribution ID: **68** Type: **Poster**

Optimisation of Electron DNN ID Working Points and charge misidentification selection in Four-Top-Quark Multilepton Analyses using Run 3 data

We present a study of electron identification (ID) working points developed by the ATLAS e-gamma group for Run 3, aiming to optimize selection strategies in multilepton final states targeting four-top-quark production. We compare the performance of the Run 2–recommended Deep Neural Network–based (DNN) ID and Charge-flip evaluated at Loose, Medium, and Tight working points. The DNN was trained on Run 2 data, though it is intended for use in Run 3 analyses. This study focuses on two key processes: the observation of Standard Model four-top-quark production using the full Run 3 dataset, and the search for
, which combines full Run 2 and partial Run 3 data. A central objective is to assess whether using looser DNN working points can improve signal statistics without significantly increasing background contamination, especially from electron charge misidentification (qmisID), which is a dominant source in same-sign dilepton and trilepton channels. The results aim to guide the optimal choice of electron ID strategy for Run 3 multilepton analyses.

Author: MOYANO GÓMEZ, Helena (IFAE)

Co-authors: Dr JUSTE, Aurelio (CERN, IFAE); Dr RIU, Imma (IFAE, CERN); Dr QIN, Quake (IFAE, CERN)

Presenter: MOYANO GÓMEZ, Helena (IFAE)

Contribution ID: **69** Type: **Talk and Poster**

Exploring a Composite Dark Matter Model Using CONTUR and MadAnalysis5

Friday 10 October 2025 12:27 (9 minutes)

In this study, we place constraints on a composite t-channel dark matter model using CONTUR and MadAnalysis 5. The model is similar to those currently being studied by the DM working group and is representative of composite dark matter constructions, with a scalar dark matter candidate and three VLQ partners (mediators). We investigate the exclusions obtained from the subprocesses in LO and NLO simulations using both of these frameworks.

Author: PRAT, Clarisse (IFAE)

Presenter: PRAT, Clarisse (IFAE)

Session Classification: Morning talks

Contribution ID: **70** Type: **Talk and Poster**

Model Independence of the γZ Box in Parity-Violating ep Scattering

Friday 10 October 2025 12:45 (9 minutes)

The γZ box correction plays a key role in precision studies of electron–proton scattering, where it impacts the determination of the weak mixing angle. Earlier calculations often relied on simplifying assumptions such as forward-scattering limits or helicity independence, which limit their applicability to real experimental conditions.

We present a new calculation that retains the full kinematic and spin dependence of the scattering amplitude, providing a more accurate description at finite momentum transfer and low energies. The results show that the correction depends strongly on the scattering conditions, highlighting the need for refined treatments. This framework improves the reliability of theoretical inputs for experiments such as P2, thereby strengthening tests of the Standard Model and searches for new physics.

Authors: DUCH, Balma (IFAE); Prof. SPIESBERGER, Hubert; Prof. MASJUAN, Pere (IFAE)

Presenter: DUCH, Balma (IFAE)

Session Classification: Morning talks

Contribution ID: **71** Type: **Poster**

Gravitational waves as probes of binary lens caustics

Mergers of compact binaries, such as black holes and neutron stars, emit gravitational waves (GWs) that can be detected by the LIGO–Virgo–KAGRA (LVK) Collaboration. As these waves travel cosmological distances, they may encounter massive astrophysical objects that act as lenses, bending their trajectories and distorting their signals. This effect, known as gravitational lensing of gravitational waves, has not yet been observed, but is expected to be within reach of current and upcoming detectors. Near caustics, lensing produces multiple highly magnified images whose signals can overlap in time, requiring accurate modeling beyond Geometrical Optics. In this poster, we present a framework to describe GW diffraction near fold caustics in binary lenses using the Uniform Approximation (UA). This approach avoids the high computational cost of full-wave methods while providing accurate, globally valid solutions. It has enabled us to characterize the caustic width, d_c, the scale over which diffraction significantly affects propagation. We find a universal scaling $d_c \sim \lambda^{2/3}$ and $d_c \sim M_{Lz}^{-2/3}$, and show that the amplification near the fold grows as $d_c^{-1/4}$. This enhanced magnification could substantially boost the detectability of lensed gravitational waves in the vicinity of caustics.

Authors: MORESO SERRA, Anna (Universitat de Barcelona); BULASHENKO, Oleg (UB)

Presenter: MORESO SERRA, Anna (Universitat de Barcelona)

Contribution ID: **72** Type: **Talk**

Red stars, green planets? Exploring habitability around active stars

Friday 10 October 2025 10:12 (9 minutes)

M dwarfs are the most common stars in our Galaxy and frequent hosts of exoplanets. Many of these stars are also highly active, producing powerful flares far more often than the Sun. The radiation released during these events can erode planetary atmospheres, but it may also provide the energy needed to trigger prebiotic chemistry. In this talk, I will review the current state of the field and show how stellar flares can be studied using space-based photometry. Then, I will discuss how correcting for observational biases challenges the traditional assumption that flares follow a simple scaling law. Finally, I will present the upcoming PLATO mission and its potential to significantly refine flare statistics.

Author: POYATOS, Julien (ICCUB)

Presenter: POYATOS, Julien (ICCUB)

Session Classification: Morning talks

Contribution ID: **73** Type: **Poster**

Gravitational Collapse at the Boundary

Holography has successfully been used to study the dynamics of strongly coupled gauge theories as they evolve over time in a fixed spacetime. However, in these cases the metric on the field theory side is taken to be non-dynamical. This implies that the framework is not suitable to be used in dynamical contexts, such as in cosmology or astrophysics, thereby limiting the potential of the correspondence. In this work, we attempt to extend the holographic framework to the most dramatic dynamical scenario possible: a gravitational collapse. We construct a model and present a procedure to simulate a gravitational collapse from an ideal fluid on the boundary in an FLRW background. The fluid/gravity correspondence is then used to approximate the corresponding bulk metric data dual to the simulated collapse. Finally, the bulk causal structure is studied, revealing the dynamical formation of a black funnel as the initial planar black hole is gradually perturbed, eventua lly reaching the boundary and opening up to relax into the characteristic funnel shape. The entropy density at the boundary is identified with that obtained using the area density of the apparent horizon in the bulk.

Authors: SERANTES, Alexandre (Ghent University); MATEOS, David (ICCUB); SOLÉ VILARÓ, Pau

Presenter: SOLÉ VILARÓ, Pau

Contribution ID: **74** Type: **Talk and Poster**

Model Independent Searches for New Physics

Friday 10 October 2025 10:39 (9 minutes)

The Standard Model (SM) of particle physics, despite its success, leaves many key phenomena unexplained. Traditional searches for new physics at the LHC rely on model-dependent approaches, each probing only a specific Beyond Standard Model (BSM) hypothesis. However, a discovery is not guaranteed if the true solution lies outside the considered models, highlighting the need for model-independent strategies such as anomaly detection. In this work, a model-independent anomaly detection technique, New Physics Learning Machine (NPLM), is studied. It frames the search for BSM physics as a two- sample test between data (D) and the SM reference hypothesis (R), comparing their compatibility rather than probing the signatures of a specific alternative hypothesis. The framework incorporates systematic uncertainties as nuisance parameters a!ecting each reference sample. Control regions are simulated to enable background estimation using data-driven techniques. A fully supervised neural network is trained to learn the likelihood ratio between R and D as a discriminator, along with a t-statistic quantifying the deviations from R. Though currently based on simulated dataset, this approach is designed for future applications to ATLAS Run 2 and Run 3 data, particularly in the context of the ATLAS general search in multilepton final states. In this work, the NPLM technique is implemented and its viability as an anomaly detection technique is studied, establishing a flexible foundation for future model-independent analyses across a wide range of realistic ATLAS BSM searches.

Author: RIJAL, Sanjay (IFAE)

Co-authors: JUSTE, Aurelio (CERN, IFAE); HARRISON, Jack (IFAE - Barcelona)

Presenter: RIJAL, Sanjay (IFAE)

Session Classification: Morning talks

Contribution ID: **75** Type: **Talk**

CosmoHub a big data platform for Astro-Cosmo data exploration and analysis

Friday 10 October 2025 12:36 (9 minutes)

The CosmoHub is a Big Data platform designed to enable the exploration and analysis of heterogeneous datasets within a unified environment. It was originally developed to serve cosmological surveys such as DESI DR1, DES, Euclid Q1, Gaia, Quaia, and Glade+, among others. It has since been extended to support the ingestion and cross-analysis of multi-messenger data. Recent integrations include public event catalogs from ANTARES, all-sky point sources from IceCube, gravitational-wave detections from LIGO/Virgo/KAGRA via GraceDB, as well as test datasets from MAGIC and CTAO.

The web portal and its underlying infrastructure have been enhanced to efficiently handle these diverse data streams. Through both guided and expert user modes, researchers can query, filter, and join datasets via compatible fields, leveraging Apache Hive and Apache Spark parallelization on a Hadoop-based architecture. These data selections can also serve as the basis for cross-correlation functions in counterpart searches. This approach empowers researchers to seamlessly explore correlations across multiple messengers, opening new avenues for discovery in the era of multi-messenger astrophysics.

Authors: DELGADO MENGUAL, Jordi (PIC-CIEMAT); Dr CARRETERO PALACIOS, Jorge (PIC--CIEMAT); Dr TALLADA CRESPÍ, Pau (PIC-CIEMAT)

Presenter: DELGADO MENGUAL, Jordi (PIC-CIEMAT)

Session Classification: Morning talks

Contribution ID: **76** Type: **Talk**

Neutral and charged pion form factors in the intermediate energy region from double dilaton HQCD model

Friday 10 October 2025 10:21 (9 minutes)

We compute the form factors of both the neutral and charged pion using a non-perturbative running of the strong coupling constant αs obtained in a previous work. These form factors remain poorly understood in the
intermediate energy region, which marks the transition between low-energy and high-energy physics. In particular, experimental data for the neutral pion form factor exhibits a deviation from the expected asymptotic behavior, and the charged pion form factor remains comparatively less explored. To address these issues, we employ the pion distribution amplitude formalism to investigate the form factor behavior in this intermediate regime. Our results suggests that non-perturbative physics of the strong interaction is relevant even at energy scales traditionally
considered perturbative, implying that the perturbative regime could occur at higher energies than previously thought.

Author: CANCIO ANDEL, Héctor (IFAE)

Presenter: CANCIO ANDEL, Héctor (IFAE)

Session Classification: Morning talks

Contribution ID: **77** Type: **Talk**

AGN outflows in dwarf galaxies using DESI

Friday 10 October 2025 12:09 (9 minutes)

Feedback from an active galactic nucleus (AGN) is one of the most important mechanisms in galaxy evolution. This phenomenon is usually found in massive galaxies and is known to regulate star formation. Although dwarf galaxies are assumed to be regulated by supernova feedback, recent studies have offered evidence to support the presence of AGN outflows and feedback in dwarf galaxies.

We investigate the presence of AGN outflows in dwarf galaxies in a sample of 59252 galaxies with outflow signatures drawn from the DESI DR1 survey.

Using the EmFit code, we fit the the different emission lines of the galaxies, and in particular, the [OIII]λ5007 Å emission line. An outflow is usually identified through the detection of a broad component in the [OIII] emission line, which traces gas characterized by non-circular motions.

We find 1599 new dwarf galaxies that present AGN outflow signatures based on the presence of a broad [OIII] emission line. This is the biggest sample of AGN outflows in dwarf galaxies to date, having multiplied the previous sample by more than a factor 10.

Author: RODRÍGUEZ MORALES, Víctor (Institute of Space Siences (ICE))

Presenter: RODRÍGUEZ MORALES, Víctor (Institute of Space Siences (ICE))

Session Classification: Morning talks

Contribution ID: **78** Type: **Talk**

From Higgs to di-Higgs to tri-Higgs

Friday 10 October 2025 09:45 (9 minutes)

Studying the properties of the Higgs boson remains a central objective of modern collider experiments, such as the ATLAS Experiment. While the discovery of the Higgs boson was a groundbreaking achievement over a decade ago, ongoing analyses continue to refine our understanding of its properties. Since then, many studies have been designed to constrain the properties related to the Higgs boson, such as its coupling to other Standard Model particles and the measurement of the coupling parameters of the Higgs potential. In this talk, it will be discussed ATLAS measurements aimed at constraining the Higgs potential, beginning with an overview of the various studies done to observe the Higgs and di-Higgs boson production. Finally, it will be highlighted the prospects of observing the tri-Higgs production and the obstacles associated with measuring the quartic Higgs coupling.

Author: OLIVEIRA CORRÊA, Gabriel (IFAE)

Presenter: OLIVEIRA CORRÊA, Gabriel (IFAE)

Session Classification: Morning talks

Contribution ID: **79** Type: **Talk**

The trichotomy of primordial black holes initial conditions

Friday 10 October 2025 09:54 (9 minutes)

We show that the threshold to form a black hole, in an asymptotically flat, radiation dominated, Friedman-Robertson-Walker (FRW) universe, is not solely (mainly) determined by the behavior of the compaction function at its maximum, as earlier thought, but also by the three-dimensional curvature at smaller (but super-horizon) scales, which we call "the core". We find three classes of initial conditions characterized by an open (O), closed (C), or flat (F) FRW core surrounded by a shell with higher three-dimensional curvature. In the case of Type O and F, the core works against the collapse of the surrounding shell. In contrast, in the C case, the core helps the collapse and the required threshold for black hole formation is the lowest among all cases. Type II black holes might only be generated by type O or F (each of those with different thresholds with O being the highest) or by a type-C with an effective F core.

Author: MONTELLÀ, Laia (ICCUB)

Presenter: MONTELLÀ, Laia (ICCUB)

Session Classification: Morning talks

Contribution ID: **80** Type: **Talk and Poster**

Electrons at LHCb: how to identify them?

Friday 10 October 2025 10:03 (9 minutes)

This work focuses on adapting LHCb's existing machine learning approach to electron identification to the upgraded conditions of Run 3. The LHCb experiment at CERN focuses on precision measurements in heavy-flavour physics, where efficient particle identification (PID) is crucial. During the last LHC Long Shutdown (2019-
2022) a major upgrade to the detector was done, including a fully-software trigger, new tracking detectors and an update of the RICH (Ring-Imaging Cherenkov) subdetectors, in order to be able to work at increased data rates. As a consequence of all these upgrades, the re-optimization of PID algorithms is then required. One of these PID algorithms is the ProbNNe algorithm, a neural network-based binary classifier, which estimates how likely a reconstructed particle is actually an electron. The model takes as input both PID and tracking information from the detector and outputs the corresponding probability. The information that serves as training samples are Monte Carlo (MC) simulations that emulate the conditions of the 2024 data-taking. After the training and tuning processes, the model is tested on independent MC samples as well as on real, recorded data from 2024.

Author: OLIVART, Ernest (ICCUB)

Presenter: OLIVART, Ernest (ICCUB)

Session Classification: Morning talks

Contribution ID: **81** Type: **Poster**

b-jet efficiency calibration in Run 2

The identification of jets originating from b-quarks is crucial for many physics analyses in ATLAS. Triggers that include b-jet requirements are critical for efficiently selecting specific signal events in multijet final states, such as HH → bbbb.
This work demonstrates the measurement of b-jet identification efficiency for b-tagging at the level of trigger only, and at the level of the combination of trigger and offline b-tagging. The combined efficiency is important for analyses that use both online and offline b-tagging as it allows consistency with those analyses that are based on offline tagging only.
The measurement utilizes data from enriched samples of dileptonic top anti-top decays. The b-tagging efficiency is calculated directly from the data using a likelihood-based approach. These efficiencies are benchmarked against simulation, and simulation-to-data scale factors are calculated to correct differences.
These updated calibrations increase the precision and confidence in the selection of b-jets in ATLAS Run 2 analyses.

Author: MITRA, Pritha (IFAE, Barcelona (ES))

Presenter: MITRA, Pritha (IFAE, Barcelona (ES))

Contribution ID: **82** Type: **Talk**

The ATLAS High-Granularity Timing Detector for the HL-LHC

Friday 10 October 2025 13:12 (9 minutes)

The increased particle flux at the High-Luminosity Large Hadron Collider (HL-LHC) will pose a significant challenge to the ATLAS detector's performance, particularly in the forward region. To address this, a novel High-Granularity Timing Detector (HGTD) will be installed in front of the liquid Argon end-cap calorimeters. The HGTD is a key upgrade for pile-up mitigation and luminosity measurement, and will augment the new all-silicon Inner Tracker in the pseudo-rapidity range of 2.4 to 4.0.

The detector will consist of two double-sided layers of silicon sensors, leveraging Low-Gain Avalanche Detector (LGAD) technology to achieve the high signal-to-noise ratio necessary for precision timing. With a granularity of 1.3 mm × 1.3 mm and a total of 3.6 to 3.7 million channels, the HGTD is designed to provide a timing resolution as good as 30 ps per track. This capability will allow for the precise assignment of charged particles to their correct vertex, thereby significantly improving reconstruction and trigger performance in the high-pile-up environment of the HL-LHC.

This talk will provide an overview of the current status and our work on developing the HGTD, from the initial assembly of the detector modules to the final testing and loading procedures that ensure the detector is ready for installation. We will cover the specific challenges and solutions encountered during these critical phases of the project.

Author: YOUBI, Issam (IFAE)

Presenter: YOUBI, Issam (IFAE)

Session Classification: Morning talks

Contribution ID: **83** Type: **Talk**

Buchdahl's limit in theories with regular black holes

Friday 10 October 2025 12:18 (9 minutes)

It has been recently shown that the Schwarzschild black hole singularity is generically resolved in $D \geq 5$ spacetime dimensions by introducing an infinite tower of higher-curvature corrections to the Einstein-Hilbert action. In such theories, Birkhoff's theorem holds, and the collapse of matter has been shown to lead to the formation of regular black holes.
In my talk, I will explain how the maximum compactness limit for perfect-fluid stars—i.e., Buchdahl's limit—is modified by these higher-curvature corrections, under the same assumption originally made by Buchdahl. I will also present plots for constant-density configurations, showing Buchdahl's limit together with other new bounds that appear within this framework.

Author: VICENTE-CANO, Aitor (ICCUB)

Presenter: VICENTE-CANO, Aitor (ICCUB)

Session Classification: Morning talks

Contribution ID: **84** Type: **Talk**

The Denario Project: Modular Automation of Scientific Research with Multi-Agent Systems

Friday 10 October 2025 10:48 (9 minutes)

I will present Denario, an AI multi-agent system designed to be a scientific research assistant. Denario can perform many different tasks, such as generating ideas, checking the literature, developing research plans, writing and executing code, making plots, and writing a scientific paper. Denario is built as a modular system, and therefore, can perform either very specific tasks, such as generating an idea, or carrying out end-to-end scientific analysis using cmbagent as a deep-research backend. In this talk, we describe Denario and its modules in detail. We publicly release the code at https://github.com/AstroPilot-AI/Denario. A Denario demo can also be run directly on the web at https://huggingface.co/spaces/astropilot-ai/Denario, and the full app will be deployed on the cloud.

Author: TARANCÓN ÁLVAREZ, Pedro (ICCUB)

Presenter: TARANCÓN ÁLVAREZ, Pedro (ICCUB)

Session Classification: Morning talks

Contribution ID: **85** Type: **Talk**

Gravitational lensing of gravitational waves

Friday 10 October 2025 11:06 (9 minutes)

What happens when gravitational waves encounter a massive astrophysical object? Gravitational lensing, traditionally seen with light, bends and distorts gravitational waves as a result of the object's gravity. Gravitational lensing can be a useful tool to learn more about the nature and the properties of these astrophysical objects (gravitational lenses), and is expected to distort gravitational waves as well. Although ~300 gravitational wave event candidates have been detected since 2015, a gravitationally-lensed signal has not been confidently observed yet, but it is expected to arrive at any moment. I will discuss how these events can be modelled: in particular, how interference and diffraction around the lens affect the signal, giving rise to characteristic features. I will also discuss how lensing of gravitational waves emitted in the same environment as the lens can help us distinguish the origin of the signal.

Author: UBACH RAYA, Helena (Universitat de Barcelona, ICCUB)

Presenter: UBACH RAYA, Helena (Universitat de Barcelona, ICCUB)

Session Classification: Morning talks

Contribution ID: **86** Type: **Talk and Poster**

Phenomenology of axion-meson mixing and scattering processes

Friday 10 October 2025 10:57 (9 minutes)

In this work, we present a comprehensive analysis of axion-meson mixing and scattering processes at leading order in three-flavor, large Nc chiral perturbation theory (ChPT). Treating the axion as a general axion-like particle (ALP) coupled derivatively to quark axial currents, we construct the effective chiral Lagrangian including meson and axion degrees of freedom, with all mixing effects consistently accounted for via a chiral rotation of the quark mass matrix.

We systematically derive the kinetic and mass mixing matrices for the neutral fields that, after the necessary rotations, give rise to the physical axion and the known neutral mesons (π^0, η, η'). We perform this diagonalization at a leading order in the ratio of the pion and axion decay constants, F/fa, and include a full analysis of the leading order isospin breaking corrections to the axion-meson mixing angles.

Having calculated the physical states of the axion and mesons, we present the full leading order 4 field Lagrangian that allows us to calculate $1 \longrightarrow 3$ decays and $2 \longrightarrow 2$ scattering processes. We present general parameterizations of those amplitudes for an arbitrary number of axions in the initial and final states and provide simple methods to calculate the coefficients these amplitudes depend on.

Our method allows us to obtain a complete and comprehensive description of axion-meson interactions at a leading order, accounting for isospin breaking, and a direct relation between the parameters of the ultraviolet theory (axion-quark couplings) and those of the low-energy effective theory (axion-meson mixing angles). Also, we provide guidelines to easily extrapolate this analysis to NLO calculations or to focus on a particular axion model, that being an ALP or the QCD axion.

The very general character of our axion model opens the door for future uses on different fields, having the possibility to search for ALPs in the ~MeV mass range on particle colliders or lighter species as a dark matter candidate.

Authors: DUARTE GONZÁLEZ, Noé (IFAE); Dr SÁNCHEZ PUERTAS, Pablo (UGR); Dr ESCRIBANO CARRASCOSA, Rafel (IFAE)

Presenter: DUARTE GONZÁLEZ, Noé (IFAE)

Session Classification: Morning talks

Contribution ID: **87** Type: **Poster**

Hit ~me baby~ Quarkonium One More Time (with QTRAJ 1.1 beyond the dipole).

In 2021, in the pursuit of a simulation framework for the propagation of quarkonium, a joint effort between Munich (TUM) and Kent (KSU) developed QTRAJ 1.0. This code, based on the Quantum Trajectories algorithm, solves Lindblad's equation numerically as long as it is expressed in an Open Quantum System (OQS) form. However, QTRAJ 1.0 could only simulate the system the dipolar limit, meaning $rT \ll 1$ being T the temperature and r the relative distance of the pair.

In our work, we present QTRAJ 1.1, an extended version that goes beyond this restriction, up to $rT \sim 1$. Following the approach of Blaizot and Escobedo (2018), which recovers Laine's original idea of the One Gluon Exchange (OGE) as the source of the complex potential, we expand the original dipolar implementation. To validate our code, we reproduce the dipolar limit, thereby demonstrating consistency by construction. By introducing new selection rules and improving numerical robustness, QTRAJ 1.1 enables predictions beyond the dipolar regime, providing a basis for future phenomenological applications.

Presenter: MANUEL MARTÍNEZ VERA, Jorge (ICCUB)