CURSO 2024/25	
Especialidad	
Física Teórica	**TEO**
Astrofísica	**ASTRO**
Física Nuclear y de Partículas	**FNyP**
Fotónica	**FOTO**

PROPUESTAS TRABAJO FIN DE MASTER EN FÍSICA AVANZADA (Curso 2024-2025)

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Núm	Tema	Tutores	Email de contacto	Especialidad	Breve descripción (máximo 300 caracteres)
1	Role of magnetic fields on astrophysical jets in magnetized accretion disk around black holes	Milton Ruiz	milton.ruiz@uv.es	ASTRO	The goal of this project is to explore the formation, energetics, and geometry of relativistic jets, with a particular focus on how magnetic field geometry influences jet launching and the variability of their central engines. Our studies will include both rapidly and slowly rotating black holes, applying our findings to active galactic nuclei and gamma-ray burst engines. Through the analysis of gravitational waves and electromagnetic signals, we seek to uncover new insights into matter at high densities.
2	Tracking dynamical matter ejection in binary neutron star mergers for nucleosynthesis processes	Toni Font/Milton Ruiz	j.antonio.font@uv.es /milton.ruiz@uv.es	ASTRO	Neutron star mergers often lead to the ejection of a small but significant fraction of a solar mass, with matter expelled at high velocities into space. Originating from the violent disruption of a neutron star, these ejecta are initially extremely dense, hot, and rich in neutrons. The neutron density is so high that rapid neutron captures occur before the unstable nuclei can decay into more stable forms, converting neutrons into protons and facilitating the formation of heavy elements. The objective of this project is to track the dynamical ejection of matter from these systems to explore the process of heavy element formation.
3	How large was the Milky Way 13 billion years ago?	Vicent Martínez & Mauro Stefanon	mauro.stefanon@uv.es	ASTRO	According to the concordance model, galaxies form and evolve following the hierarchical assembly of dark matter halos. Their gravitational potential drives the accretion of gas (mostly hydrogen) which cools down and forms stars. At each specific epoch, the size of a galaxy is the result of both in-situ star formation and accretion from galaxy mergers. Specifically, the study of galaxies sizes at different wavelengths across cosmic time provides us with a probe on the relative contribution of these two mechanisms. In this study we will use novel data from the recently launched James Webb Space Telescope (JWST), the most powerful telescope available today to study the optical and NIR Universe, to analyze the sizes of among the brightest and most massive galaxies identified at z~7, i.e., when the Universe was just about 750 million years old, and which represent potential progenitors of our Milky Way.
4	Do short-period planets cause fast-rotating stars?	Andrés Moya & Hans Deeg	andres.moya-bedon@uv.es	ASTRO	This TFM project explores the relationship between stellar rotation periods and the presence of ultra-short-period (USP) planets, which are planets with orbital periods of less than one day. The USP planet TOI-1416 b has revealed a discrepancy between the star's gyrochronological age and that indicated by other methods. We aim at test the hypothesis that the presence of USP planets may influence a star's rotation period.
5	Can we overcharge a Reissner-Nordström black hole with scalar hair through superradiance?	Nicolas Sanchis Gual / José Antonio Font Roda	nicolas.sanchis@uv.es	ASTRO	Reissner-Nordström black holes are uniquely defined by two parameters: their mass M and their electric charge Q. The values of these parameters must always be such that the charge is less than the mass Q<M, otherwise the black hole would have no horizon and we would have a naked singularity. On the other hand, the second law of black hole thermodynamics tells us that their irreducible mass (related to the area ofthe black hole) cannot decrease. The aim of this project is to numerically study the phenomenon of superradiance in a charged black hole in a cavity and the formation of solutions with scalar hair using a time evolution numerical-relativity code. Once equilibrium is reached, the configuration will be perturbed to try to return part of the charge into the black hole to decrease its area or overcharge it to find the first counterexample of the second law.
6	Spectroscopic Analysis of Gravitationally Lensed Quasars	José A. Muñoz / Carina Fian	jmunoz@uv.es	ASTRO	Recent observations have revealed microlensing variability in the rest-frame ultraviolet He II complex in lensed quasar spectra. This project aims to estimate differential microlensing between the lensed quasar images to infer the size of the emitting region associated with the He II feature. Spectra acquired with the 10m Gran Telescopio Canarias, along with other spectroscopic databases, will be used in the analysis.
7	Spin evolution of proto-neutron stars	Miguel Ángel Aloy / Martin Obergaulinger	miguel.a.aloy@uv.es	ASTRO	Just-born neutron stars after the collapse of massive stellar cores are very hot, compact objects. Since the solid crust endowing the neutron-rich matter has not formed, these objects are termed proto-neutron stars (PNS). Since PNSs inherit part of the angular momentum of the collapsing core, and since vigorous convection is expected to happen in their outer layers, they are promising sources of gravitational waves. The spin of the PNS may evolve significantly after birth. Matter can be accreted/ejected on/from the PNS surface, neutrinos are copiously emitted and carry both energy and angular momentum of the PNS, and magnetic stresses may transfer angular momentum from/to the PNS. Understanding the spin evolution of PNSs is key to predict the gravitational wave signals, which may bring valuable information about the nature of matter at densities above the nuclear matter (saturation) density. In this project, we will develop an empiric model to better understand both, the spin evolution and the associated imprint in the gravitational wave signal. The models will be calibrated using existing numerical results for the early evolution of PNSs.
8	Advanced Riemann solvers for stellar magnetohydrodynamics	Martin Obergaulinger, Miguel Ángel Aloy	martin.obergaulinger@uv.es	ASTRO	The dynamics of many objects in (stellar) astrophysics depends on the coupled evolution of the plasma and the magnetic field, described by magnetohydrodynamics (MHD). Numerical codes for simulating them are based on the conservation laws of mass, momentum, and energy describing how these quantities are transported across space via fluxes that depend, e.g., on the gas velocity and the magnetic field. In practice, several approaches, so-called Riemann solvers, can be used for translating the fluxes into a workable numerical method, each with its own trade-off in terms of accuracy vs. stability, complexity and computational costs. The goal of this project is to assess the quality a family of Riemann solvers implemented in the MHD code of our group by performing simulations of simple test problems with known solutions as well as in more complex applications from stellar astrophysics in the form of convective regions in stars and/or in supernova core collapse. The analysis will reveal which of these solvers is best suited to simulate such systems as accurately as possible.
9	Spectra of highly magnetized neutron stars	Michael Gabler	michael.gabler@uv.es	ASTRO	Neutron stars are the compact remnants of supernova explosions. A particular subclass of these stars called magnetars posses the strongest magnetic fields observed in the universe. These magnetars are thought to be connected to many astrophysical phenomena of current interest like gamma-ray bursts or fast radio bursts. The proposed TFM project focuses on the calculation of the synthetic spectra of magnetars. Due to the ultra-strong magnetic filed, the main ingredient to obtain the corresponding emission spectra is resonant cyclotron scattering. Observations show that the magnetic field around magnetars is twisted. To maintain a twisted magnetospheric field in the exterior of a magnetar, strong currents are required. These currents are then targets for resonant cyclotron scattering of photons coming from the surface of the neutron star (see Fig. 1). During this process the photons can be upscattered from typically 1 keV up to 1 MeV. To calculate the final spectrum of the photons we have a numerical tool that follows the photons in the magnetosphere with a Monte-Carlo radiation transport tool. In a first step this code should be used to calculate the spectra for a variety of magnetic field configurations (see for example Fig. 2). In the current version, the momentum distribution of the charge carriers is approximated with a flat, water-bag distribution. The second part of the TFM would consist in generalizing this to a more general distribution
10	Microphysical effects on the structure of neutron stars	Michael Gabler	michael.gabler@uv.es	ASTRO	Neutron stars are the compact remnants of supernova explosions. They have radii of the order of 10km and consist mainly of nucleons. Therefore they can be considered as the largest nuclei existing in the universe. Despite their macroscopic size, their structure and properties are still (partially) determined by microscopic effects. Two of which are e.g. i) the Landau quantization of electrons in a strong magnetic field, and ii) superfluidity of nucleons in the core of the neutron star. The first effect leads to a dependence of the composition of the matter, and hence the equation of state, on the magnetic field strength. Hence, stronger magnetic fields, will lead to a different structure of the neutron star. By constructing and using tabulated dependencies of the equation of state (i.e. a pressure P which is a function of density and magnetic field strength) one can construct non-spherical models of highly magnetized neutron stars neutron stars. Alternatively, one could study the effect of superfluidity of some nucleon specie in the core of the neutron star that affects the magnetic properties of the star.
11	Gravitational Wave Parameter Estimation Using Fisher-Rao Metric and Shape Analysis	José Antonio Font, Alejandro Torres	j.antonio.font@uv.es, alejandro.torres@uv.es	ASTRO	This Master's thesis project explores an innovative approach to improving the estimation of physical parameters from gravitational wave (GW) signals by integrating the Fisher-Rao metric with shape analysis techniques. Traditional GW parameter estimation methods can be challenged by noise and the complex nature of the data. Our goal is to develop new algorithms that leverage statistical geometry and shape analysis to more accurately and efficiently extract key source parameters like masses and spins. We plan to test these methods using signals from binary black hole (BBH) mergers and core-collapse supernovae (CCSN). The results will be compared with those obtained using Bilby, the tool utilized by the LIGO-Virgo-KAGRA (LVK) collaboration for parameter inference. This project offers a chance to contribute to advancing GW data analysis techniques, with potential impacts on our understanding of astrophysical phenomena.
12	Estudio de la extracción de la señal resonante de sucesos ttbar mediante técnicas de Machine Learning en el experimento ATLAS.	Jose Salt Cairos y Santiago González de la Hoz	jose.salt@ific.uv.es, santiago.gonzalez@ific.uv.es	FNyP	Estudio de la extracción de la señal resonante de sucesos ttbar mediante técnicas de Machine Learning en el experimento ATLAS. Se estudia el problema de análisis de física en el marco del experimento ATLAS y el uso de distintos métodos de ML. Aplicación de la eficiencia de clasificación del señal y el fondo. En particular, se estudia las discontinuidades en la precisión de BDT, se completa el estudio de errores out of the bag y se intenta implementar el cálculo de las masas invariantes para comparar con los datos del repositorio.
13	Nuevas técnicas experimentales para búsqueda de materia oscura en el rango de fotones de baja energía	Kiko Albiol	kiko@ific.uv.es	FNyP	Mejoras de detectores para futuras misiones de detección de materia oscura, mediante técnicas avanzadas de estadística incluída la Inteligencia artificial
14	Meaurement of the electroweak diphoton production with ATLAS at the LHC	Josu Cantero	josu.cantero@ific.uv.es	FNyP	The way in which the gauge bosons W,Z and gamma couple to each other is a unique prediction of the SM. In particular, by measuring the electroweak diphoton production, triple and quartic couplings between W bosons and photons can be tested. This TFM will be dedicated to develop new strategies for the measurement of the EW di-photon production using proton-proton collisions at the LHC.

15	Measuring the quantum dead-cone effect in jets originated from b-quarks using the Lund jet plane	Miguel Villaplana y Josu Cantero	miguel.villaplana@uv.es, josu.cantero@ific.uv.es	FNyP	The quantum dead-cone effect is a phenomenon which predicts a suppression of the gluon radiation emited by a heavy quark in a region collinear around the emitter. This region depends on the mass of the quark. This TFM consists on developing strategies for measuring the quantum dead cone effect using data from the ATLAS experiment at the LHC.
16	Machine Learning in the NEXT experiment to search for neutrinoless double beta decay	Neus López March	neus.lopez@ific.uv.es	FNyP	Experimental discovery of neutrinoless double beta decay would provide insights into the matter/antimatter asymmetry of the Universe. The NEXT experiment is searching for this decay in Xe-136 using a high pressure xenon gas time projection chamber with electroluminescent amplification. The goal of the proposed research is to develop a GNN based-approach to improve signal discovery sensitivity of the neutrinoless double beta decay ($0\nu\beta\beta$) search in the NEXT-100 detector.
17	Exploring new quantum regimes with advanced detector instrumentation and ML algorithms.	Adrian Irles	adrian.irles@ific.uv.es	FNyP	LUXE is an experiment that will study a new regime of quantum physics above the Schwinger limit. The research proposal consists of developing convolutional neural network algorithms to maximize the performance of the detectors of LUXE using real beam test data.
18	From Collision to Detection: Reconstructing Top Quark Properties at ATLAS	Miguel Villaplana y Marcel Vos	miguel.villaplana@uv.es, marcel.vos@ific.uv.es	FNyP	This project aims to explore the physics of the top quark within the ATLAS experiment at the Large Hadron Collider (LHC), emphasizing its role as the most massive quark and its significance in particle physics. Advanced data analysis techniques will be used to study high-energy collisions, focusing on how the top quark's properties are reconstructed in a detector like ATLAS, providing crucial insights into its behavior and interactions.
19	Perspectivas para la observación de la producción de pares de bosones de Higgs con datos de ATLAS del LHC y del High-Luminosity LHC utilizando inteligencia artificial	Luca Fiorini	fiorini@ific.uv.es	FNyP	La producción de pares de bosones de Higgs es un fenómeno estrechamente vinculado con la estabilidad del vacío y la búsqueda de nueva física más allá del Modelo Estándar. Su observación sigue siendo uno de los grandes hitos pendientes en la física de altas energías. Los experimentos ATLAS y CMS han reanudado la toma de datos en el colisionador LHC, logrando avances notables en la búsqueda de la producción de pares de bosones de Higgs. Este proyecto aprovechará tanto los datos y simulaciones del experimento ATLAS como herramientas de inteligencia artificial para analizar las perspectivas de detectar la producción de pares de bosones de Higgs, según lo predicho por el Modelo Estándar, y para explorar posibles escenarios de física más allá del Modelo Estándar. La inteligencia artificial permitirá mejorar el análisis de los datos, identificando patrones sutiles que podrían pasar desapercibidos con los métodos tradicionales.
20	Testing new interactions of the top quark and the Higgs boson	María Moreno Llácer y Marcel Vos	maria.moreno@ific.uv.es, marcel.vos@ific.uv.es	FNyP	In the absence of a concrete New-Physics (NP) discovery, model-independent parametrizations are an important tool to describe the impact of NP effects on physical observables. Recent data from the Large Hadron Collider (LHC) allows to perform global EFT (effective field theory) fits of the top, Higgs and electro-weak sectors. In this MSc work, we will explore the interplay between the different measurements and we will carry out global fits using the latest experimental measurements from colliders to set constraints on some of the SMEFT operators. Among those, the recent measurements that probe quantum entanglement using top quarks will be included.
21	Studying the most massive elementary particles (the top quark and the Higgs boson) at the LHC using machine learning techniques / Estudio de las partículas elementales más pesadas (el quark top y el bosón de Higgs) en el LHC mediante técnicas de aprendizaje automático	María Moreno Llácer	maria.moreno@ific.uv.es	FNyP	El estudio de las interacciones del bosón de Higgs (responsable de la masa de las partículas elementales) y del quark top (la partícula elemental más pesada que se conoce, más incluso que el propio bosón de Higgs) sigue siendo una de las prioridades del Gran Colisionador de Hadrones (LHC) del CERN. Estos análisis de datos requieren la aplicación de técnicas de inteligencia artificial y data science para distinguir la señal del fondo. En este TFM se estudiará uno de los procesos más interesantes en la actualidad de producción de estas partículas usando datos del detector ATLAS.
22	Studying the sensitivity of a new subdetector in Belle II for the search of long-lived particles	Vidya Sagar Vobbilisetti, Emma Torró	vsagar@ific.uv.es , emma.torro@ific.uv.es	FNyP	Despite clear theoretical and observational hints for the need of an extension of the SM, no evidence of new physics has been found so far in collider experiments. In this project we will study the sensitivity of a dedicated detector as part of the Belle II experiment for the discovery of new long-lived particles that could give an answer to some of the biggest open questions in particle physics such as the nature of dark matter. Vidya Sagar is the current Belle II VTX upgrade software and performance coordinator and Emma Torró has an extensive experience in searches for long-lived particles in colliders. The project developed in this TFM could be the starting point for a real new subdetector in Belle II.
23	Photon-detector development for the Deep Underground Neutrino Experiment	José Alfonso Soto / Justo Martín-Albo	josealfonso.soto@ific.uv.es / justo.martin-albo@ific.uv.es	FNyP	An ARAPUCA is a novel device created in the framework of the Deep Underground Neutrino Experiment to detect VUV photons in liquid argon. The candidate will participate in the characterization of an ARAPUCA constructed at IFIC. He/she will perform optical measurements in the laboratory, using gas argon and cryogenic liquids, comparing data with simulations
24	Construction and operation of the NEXT-100 muon veto	José Alfonso Soto	josealfonso.soto@ific.uv.es	FNyP	NEXT is a neutrinoless double beta decay experiment using xenon Time Projection Chambers. NEXT-100 is a detector installed at the Laboratorio Subterráneo de Canfranc (LSC) that will start taking data in early 2024. A 7m2 muon tagger based on scintillator bars readout by SiPMs will be installed in NEXT-100 to mitigate the cosmic muon background, one of the most significant. A first 1m2 prototype muon tagger is installed and operated at IFIC. The student will participate in the construction and operation of the NEXT-100 muon tagger, and the data analysis of the prototype installed at IFIC.
25	Double octupole phonon in 96Zr	Jose Javier Valiente Dobon	valiente@lnl.infn.it	FNyP	The generic concept of vibrational motion in nuclei is widespread and encompasses a great richness of phenomena. Near closed shells, where the nuclei are spherical in their ground state, the action of a residual interaction can cause the nucleus to oscillate in shape, taking on a range of octupole (i.e. pear-shaped) distortions as a function of time. The 96Zr nucleus is a perfect candidate to investigate octupole vibrations, which could also explain its unique structural features. For this reason, this year, an experiment was performed using the gamma-ray tracking array AGATA, state-of-the-art for gamma spectroscopy. The activity of the student will be devoted to the analysis of this recent data set with the objective of studying the lifetime of a octupole vibrational candidate state populated in the aforementioned experiment. In order to reach these goals, the student will be introduced in the different proceedures needed for performing the analysis as well as in the different analysis toolkits, like ROOT.
26	Gamma spectroscopy a helping hand to neutrino physics	Jose Javier Valiente Dobon	valiente@lnl.infn.it	FNyP	Experimental studies of nuclear matrix elements (NMEs) related to neutrinoless double-β decays (DBDs) and astroneutrino (ν) inverse β decays (IBDs) are essential for advancing our understanding of neutrino physics beyond the Standard Model, as well as for astro-neutrino research. Accurate theoretical calculations of NMEs are challenging due to their strong sensitivity to the nuclear models and parameters used. However, key NMEs associated with electromagnetic transition operators in both DBD and IBD processes—such as effective weak couplings—can be experimentally determined by measuring the corresponding electromagnetic (gamma) transitions from the isobaric analog states (IASs) of the relevant nuclei. To address this, we have launched an innovative experimental campaign aimed at exploring the interface between gamma spectroscopy and neutrino physics. The student is invited to join this cutting-edge project and focus on two main activities, which can be tailored according to their interest and background: i) Developing GEANT4 simulations to estimate the sensitivity of the detection setup for future experiments. ii) Analyzing data collected from the first experiment of the campaign.
27	Shell evolution in calcium isotopes	Jose Javier Valiente Dobon	valiente@lnl.infn.it	FNyP	Exotic nuclei, i.e. nuclei with an excess or deficiency of neutrons with respect to stability, are key to understanding the forces that bind nuclei together. The electromagnetic probe provides the most unambiguous observables to describe nuclear structure. One of the best examples is the electromagnetic decay lifetime of excited stated in exotic nuclei, which can be directly compared with theoretical predictions from different models (shell model, mean-field, ab-initio methods). For example, the region around 48Ca is characterized by puzzling phenomena despite being close to a double shell closure. In order to investigate how the shell structure evolves going towards the neutron-rich isotopes, an experiment was performed with the gamma-ray tracking array AGATA, state-of-the-art for gamma spectroscopy, coupled to the large acceptance magnetic spectrometer PRISMA. The isotopes of interest were populated via multi-nucleon transfer reaction 48Ca + 238U. In particular, the aim of the experiment was to identify several excited states in Ca isotopes and measure their lifetimes using the Recoil Distance Doppler-Shift (RDDS) technique and the DopplerShift Attenuation Method (DSAM) to accessing the wave function of the excited states. The candidate will take part to the analysis of the data, performing the particle identification with PRISMA and combining this information with the AGATA array to get the gamma-ray spectra and, ultimately, the lifetime of several excited states of interest.
28	Analysis of the test-beam data collected by the kiloton-scale liquid argon DUNE prototypes at CERN	Anselmo Cervera, José Alfonso Soto	josealfonso.soto@ific.uv.es / Anselmo.Cervera@ific.uv.es	FNyP	The Deep Underground Neutrino Experiment (DUNE) will be a long-baseline neutrino oscillation experiment using Liquid-Argon Time Projection Chambers (LAr-TPC) as detector technology. ProtoDUNE-HD is a 750-ton LAr-TPC prototype placed at CERN that has been exposed to a particle beam and cosmic muons from April to November 2024 to validate the LAr-TPC technology at the ton scale. The candidate will participate in the analysis of the ProtoDUNE-HD data.
29	b-jet pairing algorithms to reconstruct the Higgs boson in diHiggs searches with the ATLAS detector	Arantxa Ruiz, M. Victoria Castillo	Arantxa.Ruiz@ific.uv.es, M.Victoria.Castillo@uv.es	FNyP	In the ATLAS experiment, different b-jet pairing algorithms are being proposed to build the Higgs boson candidates in the searches for Higgs boson pair production in one of the most relevant channels, HH->bbbb. In this TFM, new methods will be studied using different machine learning techniques to improve this analysis. According to the Standard Model, with the current analysis projections, HH production is expected to be observed at the end of the High Luminosity LHC when a statistics of 3000/fb is collected combining ATLAS and CMS data. After the Higgs boson discovery, this is one of the main priorities of the LHC physics program. However, this process can be observed earlier if there is new physics beyond the Standard Model.
30	Sterile neutrino search with KM3NeT/ARCA	Alfonso Garcia	alfonso.garcia@ific.uv.es	FNyP	Various neutrino oscillation experiments have yielded unexpected results, suggesting the possible existence of light sterile neutrinos. Neutrino telescopes can search for this new particle by analyzing the atmospheric neutrino spectrum in the TeV energy range. This project will focus on using KM3NeT/ARCA to explore the existence of sterile neutrinos.
31	Diffuse neutrino flux with KM3NeT/ARCA	Alfonso Garcia	alfonso.garcia@ific.uv.es	FNyP	Since the discovery of high-energy astrophysical neutrinos by IceCube a decade ago, no other detector has unambiguously detected them. A neutrino telescope located in the Mediterranean Sea, called KM3NeT/ARCA, is competing to become the first detector in the Northern Hemisphere that observes the cosmic neutrino flux. This project will focus on analyzing data from KM3NeT/ARCA to search for a diffuse flux of astrophysical neutrinos.
32	Study of the Higgs boson Yukawa couplings using Run 3 ATLAS data	Ximo Poveda	joaquin.poveda@ific.uv.es	FNyP	This project is devoted to the development of machine learning techniques to improve the accuracy of measurements of the interactions of the Higgs boson with the top quark and the tau lepton, using data acquired by the ATLAS experiment at the LHC during Run 3.

33	Real-time follow-up of micro-quasar and recurrent novae bursts with the KM3NeT neutrinos telescope.	Vincent Cecchini	vincent.cecchini@ific.uv.es	FNyP	Neutrinos are ideal messengers for astronomy due to their ability to travel long distances without being absorbed by matter or deflected by magnetic fields. Currently the identified neutrino sources are uniquely x-ray sources at extra-galactic distances, leaving the galactic sources of neutrinos unknown. Micro-quasars and recurrent novae are two types of galactic objects that can produce powerful outbursts. This master project focuses on developing a framework for the real-time follow-up of such bursts with the KM3NeT neutrino telescope, enhancing our ability to catch these elusive signals as they happen. The student will develop its skills in software development, python programing and more generally its knowledge in neutrino detection and multi-messenger astronomy
34	KM3NeT calibration with Nanobeacons	Agustín Sánchez Losa y Francisco Salesa Greus	Agustin.Sanchez@ific.uv.es	FNyP	KM3NeT is a neutrino telescope under construction at two sites in the Mediterranean Sea, each with configurations adapted to different energy ranges, but basically forming three-dimensional arrays of photomultipliers in vertical lines suspended on the seabed. These sensors critically depend on their temporal calibration in order to reconstruct the Cherenkov light events that occur along the hundreds of metersof the detector. To this end, the detector has numerous optical beacons (called Nanobeacons, powerful LEDs that emit pulsed light) that will allow one of the detector calibrations to be carried out. With a quarter of the detectors just built and new data in situ, the student will be able to carry out some of the first calibrations with KM3NeT Nanobeacons, studying various effects and their impact.
35	Probing quantum entanglement with top pair production with ATLAS	Susana Cabrera	cabrera@ific.uv.es	FNyP	The quark Top is the heaviest elementary particle. Its large mass makes it a unique quark which decays before its hadronization and therefore, transferring all of its quantum numbers to the particles that appear in its decay chain, and more specifically the spin.The ATLAS and CMS experiments have recently detected the entanglement between the spins of top anti-top pairs at the LHC. We will explore novel observables proposed by theorists as well as refined experimental strategies to enhance the observation of the quantum entanglement among top and anti-top quarks produced in the LHC collisions and collected with the ATLAS detector. Moreover, we are aiming to explore proposed observables that will also allow us to test the Bell inequalities, and consequently, to carry out fundamental test of Quantum Mechanics.
36	Shape coexistence and Triaxial deformation in Cr isotopes	Andrés Gadea / Rosa Pérez	gadea@ific.uv.es, rosa.perez@ific.uv.es	FNyP	Chromium isotopes with N≥28 are good candidates to test rapid shape evolution from spherical to well deformed shapes close to N=40 region. The appearance of a subshell closure is confirmed at N=32 and an island of inversion is predicted to occur at N=40 from theoretical calculations. Shape coexistence and triaxial deformation will be studied through the identification of the second 0+ and 2+ states in 56Cr and measuring their lifetimes employing the Recoil Distance Doppler-Shift (RDDS) technique and the DopplerShift Attenuation Method (DSAM) to access the wave function of the excited states. The states of interest will be populated using a transfer reaction: 54Cr(18O,16O)56Cr. To reach the needed channel selectivity and for a better control the feeding of the states of interest from higher lying states, the gamma-ray tracking array AGATA, state-of-the-art for gamma spectroscopy, will be coupled to the light charged particle detector SAURON. The student will take part in the analysis of the data that will be measured in November 2024. The student will work in the analysis of the AGATA-SAURON system as well as in the determination of lifetimes with the techniques RDDS and DSAM using different softwares based on c++ and ROOT.
37	Seniority Conservation in the g9/2 Shell Towards 78Ni	Andrés Gadea / Rosa Pérez	gadea@ific.uv.es, rosa.perez@ific.uv.es	FNyP	The g9/2 orbital is the first shell in which seniority might not be conserved, but it can be preserved for a subset of solvable eigenstates (partial dynamical symmetry).For the case of 40<Z<50 isotopes, where the protons occupy the g9/2 orbital, isomeric 8+ states have been found, and their lifetimes are in agreement with the seniority scheme. However, this does not seem to be the case for the Ni isotopes, where the neutrons occupy the g9/2 orbital. For 72,74Ni, the non-observation of 8+ seniority isomers has been interpreted as evidence of a degeneracy of the 6+ states with seniority =2 and =4. The recent observation of the 8+ states in these isotopes is consistent with this interpretation while the newly observed 6+_2 in 74Ni suggests that the normal seniority ordering is recovered at up to J=4 in opposition to the shell model calculations. In order to experimentally solve the ambiguity, an experiment has been performed this year to measure the lifetimes of the 4+ states in 68Ni and 70Ni employing the Recoil Distance Doppler-Shift (RDDS) technique. Although these nuclei are not in the middle of the shell, the results are a benchmark for the collectivity in the region and help to shed light on the seniority scheme validity in the g9/2^n configurations. The nuclei of interest were populated by a multi-nucleon transfer reaction of 70Zn+238U. The target-like products were identified in the large acceptance PRISMA magnetic spectrometer in coincidence with gamma rays in the gamma-ray tracking array AGATA, state-of-the-art for gamma spectroscopy. The student will work in the analysis of the data of the AGATA-PRISMA system as well as in the lifetimes determination with the RDDS techniques using different softwares based on c++ and ROOT
38	Investigating Nucleon-Nucleon Correlations and Equation of State via Quasi-Free Scattering Reactions”	Dolores Cortina Gil	lola.cortina@ific.uv.es	FNyP	The atomic nucleus is a dense quantum system composed of strongly interacting particles. Describing the dynamics of such an interacting system is challenging. Historically, independent particle models, like the shell model, were used to simplify the description of the nucleus. However, recent results indicate that correlations within the nucleus significantly modify this picture. Among the open questions in modern nuclear physics is the investigation of how these correlations affect the properties of the nuclear system. A comprehensive study of correlations is essential for a complete understanding of nuclear behavior and can provide valuable insights into the interactions of cold, dense nuclear matter, such as in neutron stars, as well as studies at extreme densities of the equation of state. To deepen our understanding of these issues, we will use data from alpha quasi-elastic scattering reactions induced by neutron-rich isotopes of carbon, recently acquired at the FAIR R3B experiment.
39	Analysis of Gamma-Ray Data from HAWC	Sara Coutiño & Francisco Salesa	scoutino@ific.uv.es / Paco.Salesa@ific.uv.es	FNyP	This project aims to analyze gamma-ray data from the High-Altitude Water Cherenkov (HAWC) Observatory to create a Spectral Energy Distribution (SED) at very high energies (VHE, >100 GeV). The generated SED will then be modeled to explore the possible astrophysical sources and mechanisms responsible for the gamma-ray emissions observed, with a particular focus on identifying or constraining the origin of the radiation.
40	AGATA response functions	Andrés Gadea / Rosa Pérez	gadea@ific.uv.es, rosa.perez@ific.uv.es	FNyP	The state-of-the art high-resolution gamma-ray spectroscopy detector, AGATA (Advanced Gamma Tracking Array), works on the basis of the technique of gamma-ray energy tracking in electrically segmented high-purity germanium crystals. The reconstruction of the gamma-ray trajectories inside the detector requires the knowledge of the position, time and energy information of each interaction point of the gamma-rays. The Pulse Shape Analysis (PSA) algorithm provides this information with accuracy for the tracking task. The continued developments for the AGATA performance represent a great opportunity for advancing in nuclear structure studies. In particular, the assessment of the response functions in all the capabilities of AGATA to ensure more precision in the measurements. This work will focus on challenging aspects such as the AGATA response functions for angular distributions and polarization. The student will take part in the analysis of the data of the AGATA system employing different softwares based on c++ and ROOT.
41	Búsquedas de nueva física con el experimento NA64 en el CERN	Laura Molina Bueno	laura.molina@ific.uv.es	FNyP	NA64 is a world-reference fixed target experiment using high energy electron, positron, muon and hadron beams at CERN SPS accelerator to search for new physics at the sub-GeV level. The latest results achieved by the experiment using high energy electrons set the leading constraints in sub-GeV Dark Matter models. The experiment has significantly increased its collected statistics and plans to collect data in the spring of 2025. The student will participate in the analysis of 2024 data and in the preparation of the 2025 data taking campaign.
42	Beta spectrum shape studies for the prediction of the antineutrino spectrum in reactors	Alejandro Algora, Gustavo Alcala	algora@ific.uv.es, galcala@ific.uv.es	FNyP	Reactors are copious sources of anti-neutrinos. This is the reason why they are employed as particle sources for neutrino oscillation experiments. These experiments require an understanding of the primary neutrino spectrum emitted by nuclear reactors. Upgraded model calculations of the reactor antineutrino spectrum rely on a validation of the necessary corrections required for the beta transitions. In this work we propose a Monte Carlo study of a setup recently employed at the Univ. of Jyväskylä (Finland) for the measurement of the most relevant beta decay transitions contributing to the reactor antineutrino spectrum. The study will allow the applicant to learn Monte Carlo simulations of nuclear physics experiments employing Geant4.
43	Total absorption spectroscopy of odd Hg isotopes: first study of the beta decay of shape isomers in the same nucleus	Sonja E. A. Orrigo, Alejandro Algora	orrigo@ific.uv.es, algora@ific.uv.es	FNyP	The shape of a nucleus is an important ingredient in our present understanding of nuclear structure. In this framework, beta decay studies can provide information on the shape of the parent nucleus, if we are able to measure properly the beta decay probabilities to the different states in the daughter nucleus. Our group is an internationally well-known expert on the application of the total absorption technique for multiple applications, including shape determination. In this work, we propose to take part in the first steps of the analysis of a recently performed experiment at CERN, which aims to study the beta decay of shape isomers in nuclei of great interest from the perspective of shape coexistence. These nuclei include the odd-mass Hg isotopes, which are the first known case in the entire nuclear chart where two different shapes are expected to coexist within the same nucleus. The candidate will learn to handle complex experimental data using the ROOT software and, depending on the progress, calibration and characterization of the total absorption spectrometer and the use of Monte Carlo techniques might be also possible.
44	Particle acceleration with high-power lasers.	José Benlliure	jose.benlliure@csic.es	FNyP	The interaction of high-power laser pulses with matter can produce electric fields up to three orders of magnitude greater than those produced by state-of-the-art radio frequencies used in particle accelerators. Today, electrons with energies up to 8 GeV and protons up to 150 MeV have been produced by focusing 1 PW laser pulses in gaseous or solid targets with dimensions of less than ten micrometres. This emerging technology may enable the construction of smaller and cheaper particle accelerators in the near future. Students interested in this topic will have the opportunity to analyse data obtained last year in an experiment we carried out at the CLPU (Centro de Láseres Pulsados de Salamanca) to study the optimal acceleration of protons by impinging 1 PW laser pulses in different materials.

45	Determinación experimental de las propiedades electrónicas de	Nadia Yahlali, Anselmo Cervera	nadia.yahlali@ific.uv.es, anselmo.cervera@ific.uv.es	FNyP	The Deep Underground Neutrino Experiment (DUNE) is a leading-edge international experiment for neutrino science and proton decay studies, aimed at answering several fundamental questions about the nature of matter and the nature and role of neutrinos in the universe. A beam of neutrinos will be sent from Fermilab (US) to a giant scale detector, installed more than a kilometer underground at the Sanford Underground Research Laboratory (Lead, South Dakota), 1300 kilometers downstream of the neutrino source. The Far Detector (FD) based on the Liquid Argon TPC technology, will be instrumented with a complex cryogenic temperature monitoring system (TMS) to ensure a comprehensive temperature mapping of the detector and stable measurements conditions. The TFM work will focus on the participation in the characterization and calibration of the TMS in the laboratory and the simulation of the temperature profile in the LAr FD prototype and its impact on the particle detection.
46	Exploring new physics through B decays at Belle II	Vidya Sagar Vobbilisetti, Carlos Mariñas	vsagar@ific.uv.es , emma.torro@ific.uv.es	FNyP	The high luminosity of SuperKEKB, clean environment of e+e- collisions and improved detectors of the Belle II experiment provide ideal conditions to search for rare flavour-changing B decays that are sensitive to effects beyond the Standard Model. The work developed during the internship will contribute to improving the analysis tools used in such searches.
47	Vertex detector upgrade of the Belle II experiment	Vidya Sagar Vobbilisetti, Carlos Mariñas	vsagar@ific.uv.es , emma.torro@ific.uv.es	FNyP	To handle the high collision rates at the luminosity level aimed by the SuperKEKB accelerator (KEK, Japan), an upgrade of the vertex detector system is necessary. The work is to study the impact on the precision and resolution of the vertex measurements using selected benchmark physics channels, along with the potential integration with the trigger systems of the new CMOS-based vertex detector system.
48	Introducción a la transparencia inducida por metamateriales	Carlos Zapata Rodríguez	carlos.zapata@uv.es	FOTO	El tema fundamental de este trabajo de fin de máster es el estudio del fenómeno conocido como transparencia inducida electromagnéticamente que puede observarse mediante la utilización de metasuperficies fotónicas. Entre las aplicaciones que pueden derivarse de este efecto se encuentran el sensado óptico y la modulación de la velocidad de la luz.
49	Electronic Liquids in Two-dimensional Materials	Andres Granados del Aguila	Andres.Granados@uv.es	FOTO	Next technological revolution relies on the realization and manipulation of quantum degrees of freedom at room temperature. In this regard, layered materials hold great potential for advanced optoelectronic applications. Using the straightforward yet famous "scotch tape method", single atomically-thin layers can be obtained. In this project, we are looking for highly motivated students to investigate non-linear light-emission phenomena in single-layer devices (Fig. 1(A)). Unconventional spatial structures can be resolved in photoluminescence (PL) imaging experiments, such as a PL ring (or halo) as shown in Fig. 1(B), attributed to the formation of an electronic liquid. The remarkable optoelectronic properties of such liquid can be tuned by external parameters, paving the way for advanced device functionalities. The project offers a comprehensive experience, from hands-*on device fabrication* and *optoelectronic measurements* to *programming* , ideal for those eager to dive into quantum semiconductors research.
50	Synchrotron X-ray diffraction study of high-pressure phase transitions	Daniel Errandonea	daniel.errandonea@uv.es	FOTO	The study of structural phase transitions that occur as the result of the application of high pressure is relevant for solid-state physics, materials sciences, and earth and planetary sciences. Their characterization requires measurements to be made in situ at high pressures using synchrotron X-ray diffraction (XRD). This experimental methodology is suited to the study of structural phase transitions at high pressures up to pressures of 500 GPa; and therefore, provide a rich opportunity for characterizing pressure-driven phase transitions and furthering the general understanding of the mechanisms of such transitions. In this work, the student will analyze powder X-ray diffraction data collected using a diamond-anvil cell at the MSPD-BL04 beamline of ALBA synchrotron. The project is aimed to explore the behavior of oxides with technological applications under high-pressure conditions. The formation of the student will include learning how to solve a crystal structure from XRD and how to refine the structure using the Rietveld method. The project includes a visit to ALBA synchrotron as part of a team from our group to participate in data acquisition.
51	Electronic and Phonon Properties of Magnetic 2D van der Waals Systems for Next-Generation Quantum Optoelectronics	Alejandro Molina Sánchez	alejandro.molina@uv.es	FOTO	Atomically thin 2D van der Waals magnetic materials have garnered significant attention in recent years due to their potential in next-generation energy-efficient optoelectronic devices, as well as quantum technological applications. These materials exhibit a range of fascinating phenomena, including in-plane ferromagnetism and layered antiferromagnetism (both in-plane and out-of-plane), which can be externally modulated. In this project, we will conduct simulations and calculations to explore the electronic and vibrational structures of these systems using ab initio codes such as Quantum Espresso and EPW. We aim to elucidate the interplay between magnetic phases, structures and phonon modes, laying the groundwork for more complex future optoelectronic calculations. This project is in collaboration with CIC nanoGUNE (Donostia).
52	Refractive index and Fabry Perot interferences in atomically thick crystals	Marta Galbiati	marta.galbiati@uv.es	FOTO	Layered crystalline materials can be thinned by very simple mechanical methods, such as using a tape. Despite the simplicity of this technique, the emerging physics of reducing one of the dimensions below a certain thickness provides an accessible way to achieve quantum confinement, giving rise to new physical effects. In a first approximation, the optical response of these materials can be understood by assuming a refractive index equal to that of the bulk crystal. Thus, in many studies, the evolution of the dielectric functions with crystal thickness is ignored. In addition, 2D crystals form a Fabry-Perot cavity which generates interference signals that add to the optical response of the material. Hence, this work will aim the experimental study of the refractive index and Fabry Perot interference effects in 2D crystals and their dependence on the thickness and type of material to gain information on its layer-dependent optical properties.
53	Fotoluminiscencia y efecto Raman en semiconductores multiferroicos de van der Waals	Andrés Cantarero	andres.cantarero@uv.es	FOTO	Los materiales multiferroicos son aquellos que presentan simultáneamente ferromagnetismo y ferroelectricidad, siendo posible manipular o modular el magnetismo con campos eléctricos. De especial interés son aquellos cuya temperatura de Curie está por encima de la temperatura ambiente, lo que por otra parte facilita su estudio. En este trabajo se propone analizar las propiedades ópticas de un material multiferroico, el CuCrP2S6 o CuInP2S6, con un campo eléctrico aplicado, alrededor de la temperatura de Curie. Para ello, se obtendrán capas del material mediante exfoliación mecánica y se realizarán dispositivos mediante técnicas litográficas. Las medidas ópticas de emisión y dispersión Raman (dispersión por fonones y magnones) se realizarán en función de la temperatura y del campo aplicado. Se realizarán también medidas criogénicas con campo magnético para estudiar la posible aparición de una fase anti-ferromagnética a baja temperatura.
54	Low dimensional perovskites for quantum technologies with light	Guillermo Muñoz Matutano / Josep Canet Ferrer	guillermo.munoz@uv.es	FOTO	Metal halide perovskites (MHP) have become attractive materials for novel quantum optical devices. This project is dedicated to the spectroscopic optical characterization of 0D and 2D semiconducting perovskites and the analysis of the light-matter interaction, for the development of incoming quantum technologies with light.
55	Surface acoustic waves in quantum opitcs	Josep Canet Ferrer / Mauricio Morais	jose.canet-ferrer@uv.es	FOTO	Surface accustic waves (SAWs) are outstanding modulatiors for optical signals. At the single photon emission level, they can manage quantum operations and initialization of states. In this work, the student will learn how these operations occur via photon-phonon interaction. She or he will learn to develop and optimize numerically SAW devices for applicatoin in quantum optics. Experimentally, she or he will be trained to work in cleanroom environment and to employ nanofabrication methods to fabricate her or his own devices.
56	Acoustic modulation of open-cavity polariton structures	Mauricio Morais de Lima/Guillermo Muñoz Matutano	mauricio.morais@uv.es	FOTO	Polaritons are quasi-particles formed out of the light-matter interaction, in which excitons strongly couples with photons. The resulting bosonic system can be modulated by acoustic phonons in the form of a surface acoustic waves (SAWs), giving rise to plenty of interesting phenomena with possible applications in quantum technologies. In this work, the Master student will deal with the design, simulation, fabrication, and characterization of open-cavity polariton structures under the influence of SAWs.
57	Reducción de efectos de borde en detectores gamma usando LiOB	Andrés Cantarero y Andrea González Montoro	andres.cantarero@uv.es, andrea.gm@i3m.upv.es	FOTO	La modalidad de imagen médica PET (Positron Emission Tomography) es la técnica por excelencia para observar los procesos metabólicos del cuerpo humano in vivo. A pesar de su gran relevancia, el rendimiento de los escáneres PET convencionales está comprometido. Por ejemplo, en los equipos comerciales la resolución espacial en el centro es de 2.5-4 mm y degrada hasta 5-6 mm en los bordes del campo de visión. Esto se debe, en parte, a los llamados "efectos de borde" que se producen por la geometría finita del detector, ya que constriñe la distribución de la luz en las zonas periféricas del centelleador y, por tanto, dificulta el posicionamiento de los eventos en estas zonas. Para reducir estos efectos, proponemos el diseño y validación de redes neuronales que reciban como entrada las distribuciones de luz medida y devuelvan las posiciones 3D (x, y, DOI) de los impactos. Pretendemos generar unas barreras ópticas mediante láser (LiOB) en dichas zonas para modificar la distribución de luz generada y que así la red pueda aprender y calcular de manera más precisa las coordenadas de impacto. Con esto, se reducirá el efecto de borde. El plan de trabajo consiste en dos partes: i) Realización de simulaciones Monte Carlo de nuestros detectores, con y sin barreras ópticas para estudiar los procesos ópticos dominantes y las distintas geometrías de las barreras. Se entrenará y validará la red propuesta. ii) Implementación en nuestros detectores del diseño de barreras que reporte mejores resultados en la simulación, evaluándose experimentalmente. Se comprarán los valores de resolución espacial obtenidos con los reportados por el caso sin barreras ópticas.

58	Electronic properties of epitaxial graphene and related 2D heterostructures	Amilcar Bedoya-Pinto & Juan Francisco Sanchez Royo	amilcar.bedoya@uv.es / juan.f.sanchez@uv.es	FOTO	Recently, the condensed-matter physics community has celebrated the 20-year anniversary of graphene. One peculiar method to synthesize it is by modifying the surface of a Silicon Carbide (SiC) crystal via thermal treatment in ultra-high vacuum: the structure is commensurate with the one of a 6-root3 x 6 root-3 surface reconstruction of SiC and is called therefore epitaxial graphene. It has unique advantages: 1) it can be used as a low-surface energy template to grow high-quality van der Waals 2D materials with ultra-high vacuum methods and 2) it promotes the formation of a small energy gap at the Dirac point due to the interaction with the reconstructed SiC surface - making graphene semiconducting. The objective of this thesis is to prepare epitaxial graphene under various conditions and characterize the crystalline and electronic properties via in-situ electron diffraction (RHEED) and angle-resolved photoemission spectroscopy (ARPES). Special attention will be given to the detection of a possible energy gap at the Dirac point and the relation to the structural properties/growth conditions. In a second stage, 2D heterostructures consisting of functional van der Waals materials (such as 2D magnets or 2D excitonic systems) grown on the graphene surface will be fabricated by molecular beam epitaxy, with the aim of studying electronic proximity effects (modification of the electronic bands) on both sides of the 2D heterostructure.
59	Specialty nanoantennas for deterministic positioning of quantum emitters	Rosa Córdoba	rosa.cordoba@uv.es	FOTO	The development of bright quantum emitters is crucial for advancing new quantum communication technologies, as the emitter's lifetime directly affects the operation rate of quantum devices. A practical approach to enhance the emission rate in realistic devices involves placing quantum emitters at the hot spot of a nanoantenna, where the electromagnetic field is intensified. In this project, the student will begin with an introduction to the fundamentals of quantum communication protocols. Following this, she or he will explore deeper into the principles of light-matter interaction at the nanoscale, with a focus on understanding the Purcell effect and its role in enhancing emission rates. The experimental part of the project will involve hands-on training in the fabrication of nanoantennas, using established techniques in our laboratory, for further positioning of quantum emitters. Additionally, the student will gain experience in the optical characterization of single-photon emitters.
60	Laser-based synthesis of perovskite quantum dots	Jose Marques Hueso	Jose.Marques@uv.es	FOTO	It has been recently demonstrated that laser synthesis can be used to selectively synthesize halide perovskite quantum dots, as small as 10 nm, and use their ensembles as high-definition pixels. Using this novel technique, we propose to undertake the synthesis of different perovskite nanocrystals (composition and size), paying attention to the pixel size and spatial resolution of the technique. The laser synthesis of perovskite microstructures formed by quantum dots will be characterized by micro-photoluminescence, pixel by pixel, under continuous wave and pulsed excitation at room and low temperatures.
61	Electronic properties of altermagnets	Juan Francisco Sánchez ROyo	juan.f.sanchez@uv.es	FOTO	In the quest to unravel the physics behind the exotic behavior of novel materials, angle-resolved photoemission spectroscopy (ARPES) stands as, probably, the most powerful technique able to probe the electronic properties of materials with unparalleled precisión. The insights gained from ARPES not only enhance our understanding of fundamental physics but also pave the way for advancements in electronics, superconductors, exotic mangnetic materials. Recently, a new class of magnetism, called Altermagnetism, has been discovered which has shocked the scientific community, in view of its potential applications in spintronics, memory devices or even quantum computing. In this proposal, we pretend to study the electronic properties of some candidates to altermagnets by angle-resolved photoemission.
62	Relativistic electron beam interaction with carbon nanotube arrays	Javier Resta López / Jorge Giner Navarro	javier2.resta@uv.es, Jorge.Giner@uv.es	FOTO	Due to their unique geometry and exceptional electro-optical and thermo-mechanical properties, carbon nanotubes (CNTs) have found applications across various scientific and technical fields. Recently, they have garnered attention in particle accelerator physics, where CNT arrays show promise for beam manipulation and acceleration. Preliminary studies suggest that relativistic, subpicosecond electron bunches interacting with aligned, conductive CNT arrays could excite surface plasmonic modes and generate longitudinal electric gradients as high as 100 TV/m. This breakthrough could pave the way for cost-effective, ultra-compact accelerators and light sources. However, there are limited data on ionization effects, material damage, and the thermo-mechanical behavior of CNT arrays when exposed to relativistic electron beams. In this project, we aim to investigate these phenomena using a GEANT4-ANSYS model, exploring various beam configurations available at existing experimental facilities.
63	Tetraquarks with charm and beauty	Raquel Molina	Raquel.Molina@ific.uv.es	TEO	Recently, the large hadron collider has discovered a new exotic particle, the Tcc(3875). This is a flavour exotic state which can decay in DDpi. Because of heavy quark symmetry, it is expected that in the near future a particle called Tcb is discovered. In this work we will investigate how the interaction of charmed with bottom mesons can generate a resonance and tell to the experimentalist the energy range where this exotic particle should be discovered in the future.
64	Di-Higgs and Dark Matter at the LHC	José Zurita	jzurita@ific.uv.es	TEO	The current project aims to construct viable models of dark matter featuring the novel di-Higgs plus missing energy signature, and study the complementarity and interplay between standard collider "MET" searches, direct detection and indirect detection.
65	Deformaciones del espacio-tiempo y grupos cuánticos	María Antonia Lledó	maria.lledo@ific.uv.es	TEO	This project aims to revise the classification of all deformations of the Minkowski space steming from quantum grouups. We will also consider defomations of the spaces of de Sitter and Anti de SItter, at least in some particular cases.
66	Baryon and lepton number and their variants	Claudia Hagedorn	claudia.hagedorn@ific.uv.es	TEO	Baryon and lepton number are accidental symmetries in the Standard Model without neutrino masses (SM). Effects of the violation of such symmetries are studied, e.g. proton decay and mu -> e gamma. Theories beyond the SM and alternatives to the well-known baryon and lepton number are considered.
67	Higgs mechanism. Dynamics of the electroweak Goldstone bosons	Antonio Pich	Antonio.Pich@uv.es	TEO	The Higgs sector of the electroweak Standard Model exhibits the same pattern of symmetry breaking than 2-flavour QCD. Therefore, the corresponding electroweak Goldstone bosons inherit many of the properties of the well-known pions in QCD. Since the electroweak Goldstone bosons become the longitudinal components of the W and Z gauge fields, the dynamics of these gauge polarizations is heavily constrained by symmetry considerations. This TFM will analyze the scattering of longitudinal gauge bosons (W, Z), paying special attention to the unitarity constraints and the role of the physical Higgs boson. Some implications of hypothetical modifications of the Higgs couplings will also be studied.
68	Diphoton production and detection of New Phsycis and EW effects	Leandro Cieri	lcieri@ific.uv.es	TEO	This project will delve into the intricacies of diphoton production at the LHC, with a focus on unearthing subtle signals of New Physics and electroweak (EW) effects. The student will engage in cutting-edge calculations, employing advanced techniques to identify deviations from Standard Model predictions (or without EW). This research offers the exciting prospect of uncovering novel particles or interactions from the diphoton background.
69	N4LO QCD soft current	Leandro Cieri	lcieri@ific.uv.es	TEO	This project pushes the boundaries of precision in LHC physics by tackling the calculation of the N4LO soft current in QCD. This current is a crucial ingredient for advanced subtraction methods employed in Monte Carlo event generators, enabling precise predictions for collider observables. By contributing to the development of this cutting-edge theoretical tool, the student will be at the forefront of LHC phenomenology, paving the way for more accurate comparisons between theory and experiment and enhancing the potential for new discoveries.
70	Quantum Computing: Quantum Vegas Monte Carlo	Leandro Cieri	lcieri@ific.uv.es	TEO	This project explores the exciting frontier of quantum algorithms for high-energy physics by developing a quantum version of the VEGAS integration algorithm. VEGAS is a cornerstone of Monte Carlo event generators, crucial for simulating particle collisions and making precise theoretical predictions. This research will investigate how quantum computers, with their access to true randomness, can enhance VEGAS and potentially revolutionize Monte Carlo simulations in high-energy physics. This work has the potential to significantly improve the accuracy and efficiency of calculations that are essential for analyzing LHC data and searching for new physics.
71	Quantum vs Classical Effective Actions in particle physics	Jorge Portolés	Jorge.Portoles@ific.uv.es	TEO	In field theory it is possible to establish a differential equation that relates the quantum and the classical effective actions that describe the physical system. It is called the DeWitt equation. I propose the study of the generation and solution of that equation (and its relation with the equivalent path integral formulation), within elementary particle physics, We will consider the effective action of a system with two scalar particles, one much heavier than the other one, and our goal will be to obtain the effective action of that system, at one loop, upon integration of the much heavier particle.
72	Neutrino Masses, Dark Matter and the Baryon Asymmetry in a low-scale seesaw model	Juan Herrero García, Giacomo Landini	juan.a.herrero@ific.uv.es, giacomo.landini@ific.uv.es	TEO	The Standard Model fails to explain several key phenomena, including the origin and nature of dark matter, the matter-antimatter asymmetry, and the masses of neutrinos. This TFM seeks to address these issues within the framework of a low-scale seesaw model. Specifically, it explores how the freeze-in mechanism can provide a viable dark matter candidate, along with a small component of dark radiation. The analysis will include reproducing correctly the dark matter relic abundance, the baryon asymmetry and neutrino masses while obeying among others constraints coming from the Cosmic Microwave Background and Big Bang Nucleosynthesis.
73	Exploring CP asymmetries in models of neutrino masses	Pilar Hernández/Jacobo López Pavón/Nuria Rius	jacobo.lopez@uv.es	TEO	The main goal of this proposal is to study CP asymmetries in the lepton sector and their correlation with the generation of neutrino masses and, possibly, the baryon asymmetry of the universe. As a possible example we will consider the flavor violating decays of the Z boson into two leptons and study the associated CP asymmetries. Other possible asymmetries associated to collider signals might be studied.
74	Neutrino Fog: A Gateway to New Physics	Martín González Alonso y Sergio Palomares	martin.gonzalez@ific.uv.es, Sergio.Palomares.Ruiz@ific.uv.es	TEO	The first measurements of the so-called neutrino fog (nuclear recoils induced by solar neutrinos) have been recently reported. This project will study how to use this measurement, in a very simplified setup, to probe non-standard interactions.
75	Hadronic decays of polarized taus	Antonio Rodríguez / Antonio Pich	anrosanz@ific.uv.es, Antonio.Pich@uv.es	TEO	The tau is the only lepton heavy enough to decay into hadrons, involving a unique interplay between different fundamental forces. In this thesis, we propose a phenomenological study of hadronic tau decays in the case where they are polarized. First, general expressions for the corresponding decay distributions will be derived, followed by the application of advanced techniques to rigorously predict specific hadronic observables, which may be tested in future experiments.
76	CPT violation in neutral meson-antimeson oscillations	Miguel Nebot / Francisco J. Botella	Miguel.Nebot@uv.es, Francisco.J.Botella@uv.es	TEO	Neutral meson-antimeson systems are a privileged playground to test potential violations of the fundamental CPT symmetry. The goal of this project is to assess the sensitivity on this respect for different meson systems and experimental facilities, following a fully consistent approach.

77	Light states in symmetric multi-Higgs models	Miguel Nebot	Miguel.Nebot@uv.es	TEO	In the context of beyond the Standard Model extended scalar sectors shaped by symmetries, the project addresses the possibility to infer, through basic requirements on the scalar potential, properties of the spectrum such as the presence of particles with masses bounded by the electroweak scale.
78	Probing the interactions of heavy quarks to the Higgs boson from vacuum amplitudes in a quantum computer	Germán Rodrigo	german.rodrigo@csic.es	TEO	We have recently proposed vacuum amplitudes, i.e. scattering amplitudes without external particles, as the optimal building blocks for theoretical predictions at high-energy colliders. The vacuum, considered as the ground state in Quantum Field Theory, is not empty but, according to the Heisenberg principle, contains all the necessary information, which emerges in the form of quantum fluctuations. The aim of this project is to exploit this novel formalism to predict the decay rate of the Higgs boson into heavy quarks at high perturbative orders, and to encode this information in the form of a simulation on a quantum computer. These theoretical predictions can be used to extract the Yukawa coupling and the mass of the bottom quark to test their energy evolution or running from LHC data.
79	Gravitational interactions from scattering amplitudes in high-energy colliders	Germán Rodrigo	german.rodrigo@csic.es	TEO	Recently, powerful Quantum Field Theory techniques, originally developed to predict observables in high-energy colliders, have been applied to describe classical observables relevant to gravitational wave physics. This has motivated a proliferation of approaches to extract classical information from quantum scattering amplitudes. In particular, these investigations suggest that the basis of the dynamics of General Relativity is Yang-Mills theory, i.e. Quantum Chromodynamics (QCD), the theory that describes the strong interactions. The project consists in determining the deflection of light by a massive spinless/spinning object using the novel Worldline Quantum Field Theory (WQFT) formalism for classical scattering.
80	Neutrino-nucleon quasi-elastic scattering in presence of beyond Standard Model interactions	Luis Alvarez Ruso	Luis.Alvarez@ific.uv.es	TEO	Neutrinos are elusive particles that interact weakly with matter. Nevertheless, (small) deviations in these interactions from the expectations based on the Standard Model of Particle Physics are bound to have profound consequences. Future precise measurements of neutrino-nucleon cross sections combined with progress in the Lattice QCD description of nucleon form factors may open a window to seek for such deviations from the Standard Model. As a step in this direction, we propose to extend the theoretical description of the neutrino-nucleon quasielastic scattering cross section to account for generalized (beyond Standard Model) effective interactions. We shall explore the precision in both experimental measurements and QCD input that would allow to set new physics constrains.
81	Study of CP violation with hadronic Tau decays	Emilie Passemar	emilie.passemar@ific.uv.es	TEO	Studying the interactions of the Tau lepton offers an excellent laboratory to test the Standard Model and its symmetries and to give us some hints on possible new dynamics. In this work, we will investigate how to test the CP (charge-parity conjugation) symmetry violation responsible for the asymmetry between matter and antimatter in the universe using hadronic Tau decays. We will then study the physics reach at the Belle II experiment which is on-going and prospects for future Tau Charm factories.