@FlipPhysics

Monday 21 March 2022 - Friday 25 March 2022

Salon de actos del IATA

Book of Abstracts

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Origin of heavy elements: r-process in neutron star mergers and core-collapse supernovae

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Our understanding of the origin of heavy elements by the r-process has made great progress in the last years. In addition to the gravitational wave and kilonova observations for GW170817, there have been major advances in the hydrodynamical simulations of neutron star mergers and core-collapse supernovae, in the microphysics included in those simulations (neutrinos and high density equation of state (EoS)), in galactic chemical evolution models, in observations of old stars in our galaxy and in dwarf galaxies. This talk will report on recent breakthroughs in understanding the extreme environment in which the formation of the heavy elements occurs, as well as open questions regarding the astrophysics and nuclear physics involved. Observations of old stars and meteorites can strongly constrain the astrophysical site of the r-process, once the nuclear physics uncertainties of extreme neutron-rich nuclei are reduced by experiments and by improved theoretical models.

Nuclear Physics / 58

Nuclear spectroscopy for understan- ding the nuclear forces

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Nuclear forces that govern the atomic nuclei are still not fully understood. The state-of-the-art nuclear theories are dealing with the complexity of the nuclear systems governed by many degrees of freedom. In order to shed light to these advance models, nuclear spectroscopy has been proven to be of outmost importance to obtained experimental information of key nuclear observables.
From the etymology, spectroscopy is composed of spectro- which refers to optical spectra and -scopy meaning observation. Therefore, nuclear spectroscopy involves all type of experiments where radiation is emitted/absorbed by the nucleus.
This talk will review some of the key experiments on nuclear spectroscopy that have contributed to the development of our understanding of the nuclear forces.

Nuclear Physics / 61

Proton resonances in meson production

Corresponding Author(s):

The description of the proton properties from its quark and gluon substructure is a topic which is far from being well understood. The strong force binding together the constituents behaves remarkably differently at high and low energies.
The main experimental tool to probe the proton is electron scattering off proton targets. At high energies, the electrons break up the protons and the underlying physics is well understood in terms of the theory that describes the strong force between quarks and gluons. However, at low energies the connection to the physics of the constituents becomes obscured. In the data spectrum, many resonances appear as interfering and overlapping peaks whose description is highly convoluted. In addition, many of them do not follow the usual quark-antiquark (meson) or 3-quark (baryon) frameworks, thus being dubbed as exotic resonances.
In this talk, I focus on the theoretical description of the resonant contributions to the proton structure.

I also give emphasis to the exotic states, in view of the ongoing and near-future high-luminosity experiments designed for their search and improved understanding.

Nuclear Physics / 62

MYRRHA, A New Large Research Infrastructure in Belgium for Applications in Nuclear Energy and Nuclear Physics

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SCK CEN is at the forefront of Heavy Liquid Metal (HLM) nuclear technology worldwide with the development of the MYRRHA accelerator driven system (ADS) since 1998.
MYRRHA is conceived as a flexible fast-spectrum research irradiation facility cooled by Lead Bismuth Eutectic (LBE). The nominal design power of the MYRRHA reactor is 70 MWth. It is driven in sub-critical mode by a high power proton accelerator based on LINAC technology delivering a 600 MeV proton beam of 4 mA intensity in Continuous Wave (CW) mode. The choice of the LINAC technology is dictated by the unprecedented reliability level required by the ADS application.
MYRRHA is proposed to the international community of nuclear energy and nuclear physics as a large research infrastructure to serve as a multipurpose fast spectrum irradiation facility for various fields of research such as transmutation of High Level Waste (HLW), material and fuel for Gen IV reactors, materials for fusion energy, innovative radioisotopes development and production, and fundamental physics.
MYRRHA is serving since 1998, started with the FP5 EURATOM framework, as the backbone of the Partitioning & Transmutation (P&T) strategy of the European Commission and is fostering the R&D activities in EU related to the ADS and the associated HLM technology developments. MYRRHA was identified by SNETP (www.snetp.eu) as the European Technology Pilot Plant for the Lead-cooled Fast Reactor.
In 2015, SCK CEN and the Belgian federal government decided to implement the MYRRHA facility in three phases to minimise the technical risks associated to the needed accelerator reliability.
On September 7, 2018 the decision was taken by the Belgian federal government to build this large research infrastructure.
In this talk, I will introduce the basis of an ADS, the MYRRHA main technological choices and its pan-European dimension. I will focus on the project current status and, in particular, on the MYRRHA phase I, MINERVA, consisting of the first 100 MeV of the LINAC and its related targets facility.

Nuclear Physics / 63

Strongly interacting matter in the laboratory and stars

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The interplay between the experimental results generated in terrestrial laboratories and the observations coming from stellar objects is of fundamental importance for offering solutions to long-standing puzzles in the physics of strongly interacting matter under extreme conditions. In this talk I will present the work I have been developing over the years regarding dense matter at finite temperature in two main fields: the properties of hadrons in a hot and dense medium, and the study of different phases of dense matter in neutron stars.

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Reaching out Exotic Nuclei

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Nuclear Physics / 64

Thermal resonances and chiral symmetry restoration.

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We analize the role played by the thermal f0(500) state or σ in chiral symmetry restoration and propose an alternative sector (related with the thermal K∗0(700) or κ) to study O(4)×UA(1) restoration. The temperature corrections to the spectral properties of those states are included in order to provide a better description of the scalar susceptibilities χS and χκS around the transition region. We use the Linear Sigma Model to establish the relation between χS and the σ propagator, which is used as a benchmark to test the approach where χS is saturated by the f0(500) inverse self-energy. Within such saturation approach, a peak for χS around the chiral transition is obtained when considering the f0(500) generated as a ππ scattering pole within Unitarized Chiral Perturbation Theory at finite temperature. On the other hand, we show, using Ward Identities, that χκS develops a maximum above the QCD chiral transition, above which it degenerates with χKP in the O(4)×UA(1) restoration region. Such χκS peak can be described when it is saturated with the K∗0(700), which we compute in Unitarized Chiral Perturbation Theory through πK scattering at finite temperature. That approach allows us in addition to examine the χκS dependence on the light- and strange-quark masses. Finally, a comparison with the Hadron Resonance Gas is also studied in this context.

Nuclear Physics / 65

Quark mass dependence of hadron resonances

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We study the dependence of hadronic resonances on the mass of quarks through the analysis of data from QCD lattice simulations form various collaborations. Using Machine Learning techniques as the LASSO algorithm we fit lattice data in order to extrapolate them to the physical point and extract the results for the quark mass dependence for exotic resonances like Ds0 and Ds1.

Nuclear Physics / 66

New ways to shed light on neutrinoless double-beta decay

Corresponding Author(s):

Observing neutrinoless double-beta (0νββ) is undoubtedly one of the most anticipated breakthroughs in modern-day neutrino, nuclear and particle physics. When observed, the lepton-number-violating process would provide unique vistas beyond the Standard model of particle physics. However, the expected decay rates depend on coupling constants, whose effective values are under debate, and nuclear matrix elements (NMEs) that are poorly known [1]. Hence, it is crucial to gain a better understanding of the underlying theory in order to plan future experiments and to extract the beyond-standard-model physics from them.

I will discuss how the theory predictions can be improved either directly by investigating corrections to the 0νββ decay matrix elements, or indirectly by studying related processes that can be or have been measured. First, I will introduce our recent work on a new leading-order correction to the standard 0νββ-decay NMEs in heavy nuclei [2]. Then, I will discuss the relation between 0νββ-decay NMEs and other nuclear observables such as two-neutrino double-beta decay, double Gamow-Teller and double-gamma transitions. In addition, I will discuss the potential of ordinary muon capture as a probe of 0νββ decay, and discuss the results of our recent muon-capture studies [3].

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[2] L. Jokiniemi, P. Soriano, and J. Menéndez, Phys. Lett. B 823 (2021) 136720.
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Nuclear Physics / 67

Improved calculations on neutrinoless double-beta decay matrix elements

Corresponding Author(s):

Neutrinoless double-beta (0νββ) decay is a hypothetical nuclear process where two neutrons transmute into two protons, with only two electrons being emitted with no accompanying antineutrinos. The measurement of such a process would imply that neutrinos are Majorana particles (their own antiparticle) and, since lepton number would not be conserved, this would point to an event beyond the Standard Model of particle physics [1].

The 0νββ decay rate is governed by the nuclear matrix element [2]. Since no measurements are available for this process, we resort to methods of nuclear structure to calculate these magnitudes. In this case, our frame of work is the nuclear shell model, one of the most successful models for nuclear structure.

Using this model as our frame of work, we evaluate for the first time both the leading long-range and the newly acknowledged short-range contributions to the matrix element for the 0νββ decay of the nuclei most relevant for experiments [3].

In addition, we use shell model results to carry out, for the first time, more accurate calculations when combining them with ab initio quantum Monte Carlo results, which are able to capture additional correlations. We combine the nuclear shell model and quantum Monte Carlo approaches using the generalized contact formalism [4], and obtain improved results with respect to the standard shell model matrix elements.

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Nuclear Physics / 68

Nucleosynthesis in the cosmos: The ^{26}Al case

Corresponding Author(s):

Nucleosynthesis is an ongoing process in the cosmos which take place in various astrophysical environments such as massive stars, core-collapse supernovae or novae. One of the most famous example of evidence in the continuity of the process was the discovery of γ-ray from radioactive 26Al in 1982 [1]. More recently, an all-sky map of this characteristic 1809-keV γ-ray shows a distribution of 26Al in favor of massive stars and supernovae as the main progenitors [2]. Nevertheless, observational data are not enough to define precisely the source of production of 26Al and 14 to 29% of the total observed 26Al abundance are expected to have a nova origin [3].
In order to have a more precise picture of the different possible scenario, the 25Al(p, γ)26Si reaction has been studied in nuclear facilities. This reaction has a direct influence on the abundance of 26Al, by bypassing the 25Mg(p, γ)26Al reaction responsible of the production of the 26Al cosmic γ-ray emitter.

In this contribution, I'll present results which illustrate two complementary experimental domains: Mass measurement and gamma-ray spectroscopy. In 25Al(p, γ)26Si reaction, the proton capture is dominated by resonant capture to a few states above the proton threshold in 26Si. The mass value of 25Al and 26Si have an exponential contribution to the total resonant proton capture rate in 26Si. The mass of 25Al has been precisely determined via Penning traps measurement in the IGISOL facility at the university of Jyvaskyla in Finland [5]. Additionally, a recent experiment at Argonne National Laboratory in USA was performed to identify the resonant states in 26Si via γ-ray spectroscopy study using the unique GRETINA+FMA setup. This experiment came in complement to a recent spectroscopy study of the 26Si mirror nucleus, 26Mg, where a previously unaccounted l=1 resonance in the 25Al +p system was observed [5].

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Nuclear Physics / 69

Delving α and non-α structure beams induced incomplete fusion@ 4-7 MeV/A : A Role of Deformation

Corresponding Author(s):

Study of heavy-ion interactions using α and non-α structure beams at low energies [1-4] may provide a great deal of information on the in-complete fusion (ICF) reactions. In order to understand the dynamics of ICF reactions, several studies have been made and a large enhancement in cross section for α-emitting channels with respect to the calculations done with code PACE4[5] has been reported [3,7,8]. In heavy ion interactions at energies ⊠ 4-7 MeV/A, using both the strongly as well as weakly bound projectiles. A substantial contribution of ICF fraction has been observed [6-8]. To under the systematic behavior in the enhancement of cross section for alpha emitting channels is still an open area of investigation. In this scenario, the role of deformation of the projectile and target nuclei in observed significant contribution is not well understood. Present work is focused to study the role of deformation [9] of the target nuclides in the incomplete fusion reactions at energies of interest, using alpha and non-alpha structure beams. In order to understand the role of the target deformation in ICF, fourteen reactions have been studied using beams of 12C, 16O, and 19F with various targets e.g., 93Nb, 103Rh, 115In, 159Tb, 165Ho, 169Tm, 175Lu and 181Ta. It has been observed that the incomplete fusion fraction increasing in an exponentially manner with the deformation (β2) of the target nucleus separately for each projectile. This systematic behavior of ICF fraction with the deformation parameter of the target nuclei has been used to develop an empirical relation. Further, analysis is in progress and results with details will be presented during the conference. The present

work is supported by the Department of Science and Technology (DST), Delhi, India.

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Study of $\alpha-$transfer reactions with ^{7}Be in the context of nuclear astrophysics

Corresponding Author(s):

In stellar evolution, the rate of 12C(α,γ)16O reaction controls the C/O abundance ratio at the end of the helium burning phase, thus defining the further course of development. At stellar temperatures of around 300 keV, the cross section of 12C(α,γ)16O is ~ 10−17 b, which cannot be measured using current technology. The α−capture reaction populating the natural-parity states of the residual nuclei, is an effective indirect tool for studying these types of reactions. In this case, it corresponds to the alpha pickup by 12C to populate states of 16O, predominantly the 6.917 MeV state. Loosely bound stable nuclei with prominent α−cluster structure, such as 6,7Li, 11B have also been used in such studies provided that these are "direct" α−transfer and do not proceed via a compound nucleus. However, the breakup contributions from such nuclei have a significant impact on the transfer channels. Interestingly, the 7Be nucleus, though having an α−cluster structure and a lower breakup threshold of 1.58 MeV, demonstrates lower breakup contribution compared to transfer cross section. In this context, we carried out an experiment at HIE-ISOLDE, CERN, with 7Be + 12C at E = 5 MeV/A to study α−transfer reactions populating states in 16O, that dominantly contribute to the He-burning process. Preliminary results would be presented.

Nuclear Physics / 71

Searching for the nuclear Cooper pairs

Corresponding Author(s):

The pairing interaction induces nucleon-nucleon correlations that are essential in defining the properties of finite quantum many-body systems close to their ground states. A very specific probe of this pairing component in the nuclear interactions, which ties up nucleons in a highly correlated state, the nuclear Cooper pairs, is the two-nucleon transfer reactions. How paring correlations can be probed in heavy-ion collisions, is still an open question. Several experiments have been performed in the past, searching for signatures mainly via extraction of the enhancement coefficients, defined as the ratio of the actual transfer cross section and the prediction of the model using uncorrelated states. Unfortunately, experimental evidence of these factors is marred by the fact that all existing studies involve reactions at energies higher than the Coulomb barrier, where the reaction mechanism is the result of the interplay between nuclear and Coulomb interactions.

With the development of the new instrumentation, it nowadays became possible to measure the heavy-ion transfer reaction with high efficiency and good ion identification even at very low bombing energies where nuclei interact at large distances [1]. Multinucleon transfer reactions were measured in the 206Pb + 118Sn system at the INFN-LNL accelerator complex. The measurement has been performed in the inverse kinematic, by using the heavy 206Pb beam, and by detecting the lighter reaction fragments in the magnetic spectrometer PRISMA. The total cross sections of different transfer channels will be extracted in an energy range from above to well below the Coulomb barrier. By direct comparison of one- and two-nucleon transfer probabilities (one expects that the probability for the two-nucleon channel is proportional to the square of the single-particle one) we will extract the enhancement factors at the large distances. In the second stage, the experimental results will be compared with the state-of-the-art microscopical calculations which include correlations [2].

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Nuclear Physics / 72

Constraining the nuclear equation of state

Corresponding Author(s):

Nuclear equation of state (EOS) describes the relationship between state variables such as density, pressure and temperature of a nuclear system. It is usually expressed as the energy per nucleon of a particular nuclear medium. Constraining parameters of nuclear EOS of asymmetric nuclear matter (where asymmetry lies in proton to neutron number) is of immense importance for understanding not just the properties of neutron-rich nuclei but also for the physics of neutron stars, mergers and other astrophysical phenomena. To accomplish this goal in terrestrial laboratories one must probe observables sensitive to changes in EOS parameters of exotic unstable nuclei which were for a long time experimentally unreachable. With the advent of radioactive ion beam facilities, the region further from the valley of stability became accessible.

An experiment with the aim of constraining the symmetry-energy slope L to ±15 MeV was held recently using large acceptance spectrometer R3B-GLAD at the GSI accelerator facility as a part of the FAIR Phase-0 campaign \cite{r3b}. Gathered data will be used to obtain total reaction, charge changing, total neutron-removal and total Coulomb-excitation cross sections along the tin isotopic chain for 124,128,132,134Sn. The objective behind the choice of these measurements lies in the existence of correlation between neutron-removal and Coulomb-excitation cross sections and the respective observables familiar for having a tight connection with the parameter L: neutron-skin thickness and the ground-state dipole polarizability \cite{tom, maza}. Stringent constraints on L will be derived from comparison of cross sections extracted from data with predictions of RMF calculations employing different energy density functionals.

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Nuclear Physics / 73

New lifetime measurements for the 2_1^+ level in $^{112,120}Sn by the Doppler-shift attenuation method

Corresponding Author(s):

The tin (Sn; Z = 50) isotopes constitute the longest chain of semi-magic even-even nuclei between the 100Sn (N = 50) and 132Sn (N = 82) double-shell closures, seven of which, 112,114,116,118,120,122,124Sn, are stable. These isotopes have become a prototypical benchmark of extensive microscopic theory and experiment, reflected in the large number of studies investigating the decay of their low-lying first-excited 2+ excited state. The transition characteristics are inferred through the B(E2; 0+g.s.⟶2+) values, which, in principle, are contingent on the lifetime of the corresponding level, and are the most direct and unambiguous test of the collective nature of the transitions.

There has been a considerable interest focused on the study of enhancement or suppression in collectivity of the excited 21+ state in the stable Sn isotopes. Independent experiments on Coulomb excitation, heavy-ion scattering and 21+ level lifetime measurements report discrepant transition probabilities, with the lifetime estimates indicating significantly reduced collectivity. A re-examination of the same has been carried out in the present work on two of the stable isotopes, 112,120Sn.

Low-lying levels in the 112,120Sn isotopes have been excited by inelastic scattering with heavy-ion beams. Level lifetime measurements have been carried out using the Doppler shift attenuation method, wherein the Doppler affected γ-ray peaks from the decay of the 21+ level in each isotope have been analyzed using updated methodologies, and corresponding B(E2; 0+g.s.⟶2+) values become indicative of the underlying collectivity. The present results are compared with existing estimates of the B(E2; 0+g.s.⟶2+) values in the stable Sn isotopes. The results are also found to be in good agreement with generalized seniority model as well as state-of-the-art Monte Carlo shell model (MCSM) calculations.

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Collinear Laser Spectroscopy and Fluorescence Detection

Corresponding Author(s):

Collinear laser spectroscopy provides access to many nuclear properties such as isotopic shifts of the nuclear mean square charge radii, spins, nuclear magnetic moments and electric quadrupole moments. As measurements are carried out on a small time scale, this method is well suited for the investigation of isotopes far from stability.
The development of many different techniques used in collinear laser spectroscopy has led to very small line widths of measured resonances (several 10MHz [1]). As these developments are always on going, additionally to the basic method new ideas for the fluorescence detection region of collinear laser spectroscopy apparatuses are presented and discussed.

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Writing and speaking skills / 76

How to write an ERC proposal

Corresponding Author(s):

In this talk I will present my experience with the ERC grant application. I will share tips and tricks for the preparation phase, the proposal writing, and the interview. The talk will be based on my personal experience with the ERC Consolidator call 2020.

Writing and speaking skills / 77

Writing skills for science outreach

Corresponding Author(s):

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Public speaking skills for science

Corresponding Author(s):

Gender equality in Science / 80

HORIZON EUROPE SEX & GENDER ANALYSIS IN RESEARCH

Corresponding Author(s):

Horizon Europe establishes Gender Equality as a cross-cutting principle and aspires to eliminate gender inequality and its intersection with other socio-economic inequalities through R&I systems, including and addressing unconscious biases and systemic structural barriers.
In order to achieve Gender Equality, the integration of the gender dimension into R&I content is mandatory and is a requirement set by default across all Work Programmes, destinations, and topics of Horizon Europe.
Addressing the gender dimension in research and innovation thus entails considering sex and gender in the whole R&I process: from the definition of the title to the methodology, the sample, the analysis, the language used and the dissemination of results.
The gender composition of the team and the existence of a Gender Equality Plan in the institution are tiebreaker and an eligibility criterium respectively.

Gender Equality in Physics / 81

String theory and gender: a European experience

Corresponding Author(s):

In March 2013 the COST Action MP1210 The String Theory Universe was initiated for a duration of four years. The objectives were mainly scientific, but we were comitted to take a series of actions to address the problems that women that want to pursue a scientific career confront.
Given the huge imbalance in the area (only 15% of the Action members were women) we thought that the problems were severe and something had to be done.
In this talk I will speak about the initiatives that we took in order to make visible these problems to all of our colleagues and favour a change of perspective.
I think that our conclusions are still valid today.

Gender Equality in Physics / 27

Organization of gender-balanced events: a case of practice, National Meeting in Optics 2021

Martina Delgado-Pinar[1] ; Alba De las Heras[2] ; Francesca Gallazzi[3] ; Mario García Lechuga[4] ; Ana I. Gómez-Varela[5] ; Rosa Ana Pérez-Herrera[6] ; Daniel Puerto[7] ; Luis A. Sánchez[8] ; Beatríz Santamaría[9] ; María-Baralida Tomás[7] ; Verónica González-Fernández[10] ; Maria Viñas[11]

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[7] *Universitat d'Alacant*

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[9] *Universidad Politécnica de Madrid*

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Organization of gender-balanced events: a case of practice, National Meeting in Optics 2021

Speaker: Martina Delgado-Pinar, Vice Chair of the Women in Optics and Photonics Committee of SEDOPTICA, in representation of the organizing committee of RNO2021
https://www.rno2021.es/#comite-organizador

A clear example of the gender imbalance in STEM fields is the under-representation of women scientists in the most visible events (plenary and invited talks) at conferences and workshops. The phenomenon of all-male panels is not unusual, although it is true that, in recent years, they have been denounced by researchers themselves as a case of misconduct.

To overcome this barrier for women, a collective effort must be made by the entire scientific community. In this respect, the involvement and support of scientific societies and institutions is crucial in order to positively reinforce measures against gender bias in the organization of events. The example that will be presented in this contribution is the organization of the National Meeting in Optics 2021 (www.rno2021.es), which was carried out by the Women in Optics and Photonics Committee (MOF, for its acronym in Spanish) of the National Optical Society in Spain, SEDOPTICA (www.sedoptica.es).

SEDOPTICA approved in 2020 an internal code of conduct for its committees with a series of recommendations for the organization of gender-balanced events. This code of conduct was drafted and promoted by SEDOPTICA-MOF, and included aspects such as the ratio of men/women in invited and non-invited talks, scientific committees and the need to avoid the usual allocation of administrative roles to women while men hold the more visible and science-related positions. This code can be read in [1].

In 2021, the National Meeting in Optics (RNO) 2021 was organised by SEDOPTICA-MOF. It is a triennial congress organized by the SEDOPTICA, which has been held for more than 30 years. Each RNO brings together an average of 200 professionals from the different topics of Optics and Photonics in Spain and is where the latest scientific and technological advances in this field are presented. The 2021 organizing committee placed special emphasis on creating an equal and attractive congress for females and younger researchers.

To this end, the organizing committee wanted to highlight the role of women in Optics and Photonics, with a dedicated topic at the meeting, and a round table to discuss gender issues in scientific careers, with the participation of four leading women in research and industry. The plenary speakers were two world-leading researchers: Professor Jannick Rolland (University of Rochester) in visual science and imaging, and Professor Jelena Vucovick (Stanford University) in quantum and nonlinear optics. It is worth noting that these two women were delighted to participate in this national meeting, even when their schedules were difficult to fit into the meeting's timetable, and we are sure that the nature of the event was a reason for them to collaborate with us. Their talks were recorded and can be viewed at [2].

In addition, special care was taken to ensure a balanced ratio of male and female speakers at every session. Remarkably, it is worth noting that even in areas such as Optoelectronics, a committee that has a proportion of women below 20%, the proportion of female speakers was approximately 50%. Another example of positive action is that the participants in the competition for the best contribution by young researchers, RNO2021 award, showed an approximately 50% ratio between men and women. Even when there were no explicit criteria for including gender aspects in the evaluation of the contribution, there were three women among the five finalists in the context. These last three data indicate that the scientific level of female researchers is as good as that of their male counterparts. Hence, the usual argument relating the lack of women in representative positions in science to scientific reasons does not apply when women have the right conditions for their participation.

As the code of conduct approved by SEDOPTICA states, the imbalance between men and women in STEM fields is no reason to disregard the possibility of equal and diverse events maintaining a high scientific level. RNO2021 is an example of this. The crucial point is to get out of the usual comfort zone for the selection of speakers and, in the case of not directly knowing women in certain fields, just get out of your personal circle and ask other researchers for suggestions. There are more and more associations and initiatives that can help with this, so: take action!

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[2] Prof. Jannick Rolland https://www.youtube.com/watch?v=MSzqeqh2DS4
Prof. Jelena Vucovick https://www.youtube.com/watch?v=EzhiOkpmGlc
Last visit 15/01/2022

Gender Equality in Physics / 82

Physics and Maternity Round table

Corresponding Author(s): , ,

Motherhood has a huge impact on the careers of women scientists. With regards to the impact of family life on the work of male and female researchers, the evidence shown here indicates that having children clearly seems to be detrimental to a woman's career in science. For men, however, if family does have an effect on their work, this effect is more positive than negative. It seems to be evident, in light of the findings, that rearing children clearly interferes in the scientific productivity of women and the possibility of them being promoted to a higher level when their productivity is the same. This conflict between family and profession for women scientists is clearly shown in the distribution of male and female academics in Spain by family situation. The INE Human Resources Survey reveals that only 38% of women Full Professors have children, as opposed to 63% of men, and that the percentage of single women is 21% as opposed to 15% of single men.

Keynote speaker: Dr. Isabel Torres (co-founder and chief executive of "Mothers in Science"). Participants: Dr. Núria Garro (Dpt. Applied Physics, UVEG) and Dr. Susana Planelles (Dpt. Astronomy and Astrophysics, UVEG). Chair: Prof. Pas García (Dpt. Optics, UVEG).

Machine learning / 83

An introduction to Machine Learning in Particle Physics

Corresponding Author(s):

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Boost Radiation Hardness Assurance in your Space Mission with Machine Learning

Corresponding Author(s):

PRECEDER (Prediction of the Electrical Behavior of Electronic Devices under Radiation, Spanish acronym) is a new concept in the strategy of ensuring the radiation hardness in electronics, developed by our group. The idea is based on the use of archival data to assess the risk associated to radiation environments without irradiation testing needs. A critical step of Radiation Hardness Assurance (RHA) for space systems is given by the parts selection in concordance with the expected radiation effects. Radiation testing is the most decisive way of studying the radiation degradation.

However, the increasing use of COTS (Commercial Off-The-Shelf) devices and the New Space challenges are pushing the need of finding new approaches to assess the risk associated to the radiation environment.
PRECEDER applies the methodology of Machine Learning searching the appropriated algorithm and finding solutions quality assessment. The development of this tool includes the search for optimal usage of the accumulated data, the search for learning methods, the analysis of application features and predict the behavior of EEE (Electrical, Electronic and Electro-mechanical) devices under radiation.
In this work, the methodology and application that has been established will be shown. The first successful results, obtained for specific devices and conditions, will be presented as a practical example.

Machine learning / 85

Forecasting hazardous Geomagnetically Induced Currents for Spanish critical infrastructures by using AI

Corresponding Author(s):

In the last decades, our society has become more interdependent and complex than ever before. Local impacts can cause global issues, as the current pandemic clearly shows, affecting the health of millions of human beings. It is also highly dependent on relevant technological structures, such as communications, transport, or power distribution networks, which can be very vulnerable to the effects of Space Weather. The latter has its origin in solar activity and their associated events, such as solar flares and coronal mass ejections, which may provoke disturbances, interruptions, and even long-term damage to these technical infrastructures, with drastic social, economic and even political impacts. However, these phenomena and their effects are not yet well understood, and their forecast is still in the early stages of development. This talk will present our project, which uses a multidisciplinary approach, and which aims to deeply understand and develop an early warning system to evaluate the impact of violent solar storms on Spanish critical infrastructures such as the power transmission grid, railways, and oil and gas pipelines. Specifically, we are developing an advanced machine learning based predictive model of the impact of future solar storms on the ground. This model will consist of two distinct stages. First, we are using as input real-time data from the solar wind space probe ACE (located at the L1 point in space) to develop a deep learning model taking into account past conditions to predict the variation of the magnetic field on the Earth's surface at different locations in the Iberian Peninsula. Second, we will feed these local predictions of time-variation of the magnetic field into a physical model of the 3D Earth's geoelectrical structure to generate the geoelectrical fields that drive the geomagnetically induced currents (GICs). Thus, the ultimate goal is to provide a real-time prediction of the GICs from extreme geomagnetic storms on the Spanish critical infrastructures. This talks will show our latest results and our prospects in this field.

Medical Physics / 86

The rise of precision medicine: the valuable contribution of medical physics

Corresponding Author(s):

Medical Physics / 87

Applications of Machine learning in Medical Physics: Risks and Benefits

Corresponding Author(s):

In this talk, we will present the application of machine learning techniques to address many medical physics problems such as positron range correction in PET, dose estimation in radiotherapy planning, the guidance of ultrasound acquisitions, tissue segmentation, automatic lesion detection… We will focus on the risks and potential benefits of these new techniques compared to current standard methods. A summary of the most common challenges in the implementation of these techniques and how to overcome them will be also presented. In conclusion, machine learning tools have the potential to revolutionize all the areas of physics, providing solutions beyond what is currently possible, and being so new, it is a great field for young researchers.

Medical Physics / 88

High-Gradient S-band Backward Travelling Wave Accelerating Cavity experiments at IFIC

Corresponding Author(s):

High gradient radiofrequency (RF) accelerating cavities are one of the main research lines in the development of compact linear accelerators. A particular focus of these structures is for medical hadron therapy applications. However, the operation of such cavities is currently limited by nonlinear electromagnetic effects that are intensified at high electric fields, such as dark currents and RF breakdowns. A new normal-conducting High Gradient S-band Backward Travelling Wave accelerating cavity for medical application (v=0.38c) was designed and constructed by the TERA Foundation in collaboration with CERN. This cavity is being tested at the IFIC High-Gradient (HG) Radio Frequency (RF) laboratory. The main goal of the tests is understanding which is the maximum achievable accelerating gradient of this new design and characterize the dark current and breakdown formation in the structure, which could limit the applicability of this technology. In this work, we present experimental measurements and simulation results characterizing the nonlinear effects of this new accelerating cavity and first conclusions about its applicability are discussed.

Medical Physics / 89

Status of the PETALO project

Corresponding Author(s):

PETALO (Positron Emission TOF Apparatus with Liquid xenOn) is a new concept that seeks to demonstrate that liquid xenon (LXe) together with a SiPM-based readout and fast electronics, provide a significant improvement in the field of medical imaging with PET-TOF. Liquid xenon allows a continuous medium with a uniform response avoiding most of the geometrical distortions of conventional detectors based on scintillating crystals. PETit, the first PETALO prototype built at IFIC (Valencia), started operation in July 2021. It consists of an aluminum box with a unique volume of LXe and two planes of SiPMs that register the scintillation light emitted in xenon by the gammas coming from a Na22 radioactive source. After some months of data taking PETit is expected to demonstrate the potential of the technology, providing measurements of the most relevant features: reconstruction of the position, energy and time of the interactions.

Quantum Computing / 90

Tensor Networks: from Quantum Information to Quantum Many-Body Physics and Quantum Field Theory

Corresponding Author(s):

The term Tensor Network (TN) States designates a number of ansatzes that can efficiently represent certain states of quantum many-body systems. In particular, ground states and thermal equilibrium of local Hamiltonians, and, to some extent, real time evolution can be numerically studied with TN methods. Quantum information theory provides tools to understand why they are good ansatzes for physically relevant states, and some of the limitations connected to the simulation algorithms.
While originally introduced in the context of condensed matter physics, where they have become a state-of-the-art technique for strongly correlated one-dimensional systems, in the last years it has been shown that TNS are also suitable to study lattice gauge theories and other quantum field problems.

Student session / 91

Topological superconductivity and Majorana modes for quantum computation: a materials science perspective

Corresponding Author(s):

My name is Elsa Prada and I am a theorist with 20 year experience in condensed matter physics. I am interested in systems where quantum phenomena play an important role, such as low dimensional materials and nanostructures, and the technological applications we can derive from such quantum properties. This is nowadays dubbed the field of "Quantum Technologies". During my career I have worked on a diverse range of problems within condensed matter, including quantum information and entanglement based on superconducting heterostructures; electronic, spintronic and optoelectronic properties of two-dimensional crystals such as graphene, phosphorene or transition metal dichalcogenides; and more recently theory and applications of topological insulators and superconductors.

In this talk I will focus on my work in topological superconductors based on superconducting-semiconducting nanowires. These hybrid wires are by far the most explored (both theoretically and experimentally) and the most advanced candidates to achieve topological superconductivity. I will discuss the appearance of exotic emergent quasiparticles at the edges of these wires, called Majorana bound states or Majorana modes. These quasiparticles share properties with the fundamental particle Majorana fermion, but they possess non-trivial exchange statistics that turn them into anyons, which could make them useful candidates for quantum-bits, qubits, of future topologically protected quantum computers. I will summarize the advancements of the field during the last decade and the problems we still face to unambiguously create and detect Majorana modes in condensed matter systems.

Student session / 92

PET detectors, from benchtop to the clinics

Corresponding Author(s):

Positron Emission Tomography (PET) imaging constitutes the molecular imaging technique of excellence and is used to evaluate a radio-tracer uptake by an organ. To obtain PET images, patients are

injected with radioisotopes that decay inside the patient body emitting a positron that subsequently annihilates with a core electron of the patient body, emitting two opposite 511 keV gamma-rays. PET detectors are optimized for the specific energy of 511 keV and their operation principle is based on opposed detectors measuring in coincidences these two emitted gamma-rays.
After complex image reconstruction processes a tomographic emission image is generated. To provide high quality images, in addition to the reconstruction process, PET detectors have to be carefully designed and optimized. Key elements are the scintillation block, the photosensor and the readout electronics.
In this talk, the design, optimization, and implementation of these components is reviewed, starting at the laboratory level, overviewing the PET scanner assembly, and finishing with their translation into the clinics.

Student session / 93

Career path of Paula Tuzón, physicist and actual secretary of climate emergency of the GVA

Corresponding Author(s):

Poster session / 139

Contribution of the $\Delta(1232)$ resonance in the pion photoproduction on Carbon-12

Corresponding Author(s):

Poster session / 138

Study of Exotic Hidden Heavy Flavor States

Corresponding Author(s):

In recent years, a great experimental effort has led to the discovery of some exotic states found in the charmonium and bottomonium spectra. Some examples of such states are the Zc(3900), Zc(4020), Zcs(3985), Zb(10610) and Zb(10650). These states do not fit the conventional qq¯ quark model given that they contain hidden-charm (cc¯) or hidden-bottom (bb¯) components, but they are also found to be charged. This implies a minimal structure of four valence quarks. Although there exist several exotic models which could describe these states, the molecular one is appealing due to the closeness of these states to the thresholds of some D(*)D¯(*) and B(*)B¯(*) channels. Within this framework and making use of SU(3) light flavor symmetry, we predict the masses and widths of additional Z states which remain to be seen in the experiment.

Poster session / 141

Implementation of a software defined radio (SDR) based beam current monitor for Schottky detectors in heavy ion storage rings

Corresponding Author(s):

With the increasing sensitivity and precision of resonant Schottky detectors, this technology becomes more valuable in the determination of masses and lifetimes of the yet unstudied nuclei inside heavy ion storage rings but also in general storage ring physics. At present, information from these detectors is gained by high-end units with software and hardware interface that are not versatile and / or not suitable for applications where scalability is indispensable. Here, software-defined radio (SDR) based data acquisition systems come in handy, mainly due to their low cost and relatively simple hardware but also due to the fact that their functionality is almost entirely software-defined/programmable. If calibrated, Schottky detectors can facilitate beam current measurements that are orders of magnitude more sensitive compared to existing DC current transformers (DDCT). In this work, we report on the implementation of an SDR-based online beam current monitor for use with Schottky detectors in heavy ion storage rings such as ESR in GSI/FAIR.

Student session / 94

Perspective of how is working outside academia

Corresponding Author(s):

Poster session / 142

Gender socialization and the absence of women in science

Corresponding Author(s):

In this presentation, we analyse how gender stereotypes influence the choice of professional career. In particular, we discuss how patriarchal social conditioning implies a lower presence of women in science. We depict possible measures to achieve greater equity in an area as masculinized as the scientific one.

Poster session / 143

Advantages of Tomosynthesis for COVID-19 Detection with Artificial Intelligence

Corresponding Author(s):

Medical imaging has been one of the main tools employed during the COVID-19 pandemic for diagnosis and disease progression assessment. The most commonly used have been Chest X-Rays (CXR) and Computed Tomography (CT). However, CXR has a limited sensibility, while CT is more expensive, less accessible, gives more dose to the patients, and requires sanitizing the scanner after each patient acquisition. Tomosynthesis, which obtains X-rays images from a few source positions, has been proposed as a good compromise between both modalities.
The use of Artificial Intelligence (AI) tools to analyze medical images of COVID-19 patients has been proposed by many groups. It has been shown that Neural Networks (NN) can be trained to detect COVID-19 affections accurately provided enough cases are available. Nevertheless, while many public databases of CXR and CT images of COVID-19 patients have been generated worldwide, there is a lack of databases of tomosynthesis images, which makes it difficult to train a NN for this modality. In this work we propose to use the existing CT and X-ray databases to perform realistic simulations

and generate X-Ray tomosynthesis images. We made use of a database containing 200 CT images of COVID-19 patients, along with the segmentations of the lung affected region. Projections at 0^o and $\pm15^o$ were simulated in an in-house developed, GPU-accelerated, ultrafast Monte Carlo (MC) code. Two NN were trained to detect whether each lung is affected by COVID-19 or not: the first one is defined with one input channel corresponding to the 0^o projection (which corresponds to a standard CXR), while the other one employs three input channels corresponding to 0^o and $\pm15^o$ projections (which corresponds to a simplified tomosynthesis acquisition). Results show that the three-channel NN outperforms the one-channel NN. Despite the limited number of cases used in this work, and the reduced number of projections, the results are very promising, and motivates further research on the advantages which can be obtained with Tomosynthesis.

Poster session / 144

Neural networks for reconstruction of the underlying kinematics in high energy collisions

Corresponding Author(s):

The parton-level kinematics plays a crucial role for understanding the internal structure of hadrons and improving the precision of the calculations. To better understand the kinematics at the partonic level, we study the production of one hadron and a direct photon, including up to Next-to-Leading Order Quantum Chromodynamics and Leading-Order Quantum Electrodynamics corrections. Using a code based on Monte-Carlo integration, we simulate the collisions and analyze the events to determine the correlations among measurable and partonic quantities. Then, we use these results to apply Machine Learning algorithms that allow us to find the momentum fractions of the partons involved in the process, in terms of suitable combinations of the final state momenta.

Poster session / 145

Cabibbo suppressed single pion production off the nucleon induced by antineutrinos

Corresponding Author(s):

In this work we study the $\Sigma\pi$ and $\Lambda\pi$ production off free nucleons driven by the strangeness-changing weak charged current. We calculate the total cross sections for all possible channels and estimate the flux-averaged total cross sections for experiments like MiniBooNE, SciBooNE, T2K, and Minerva. The model is based on the lowest order effective SU(3) chiral Lagrangians in the presence of an external weak charged current and contains Born and the lowest-lying decuplet resonant mechanisms that can contribute to these reaction channels. We also compare and discuss our results with others following similar and very different
approaches.

Student session / 95

Discussion with researchers at IFIC and UV

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Poster session / 146

Dark matter gamma-ray signals in the Milky Way: brightest dark satellites versus diffuse galactic emission”

Corresponding Author(s):

Poster session / 147

Core-collapse supernovae from red super giant stars

Corresponding Author(s):

Supernova (SN) explosions are one of the most energetic events in the observable universe.
Given that, they are the best natural laboratories to investigate extreme physical phenomena, that otherwise would not be reproducible on Earth.
During these powerful explosions chemical elements are also produced, that go to enrich the amount of heavy elements in the interstellar medium.
Three-dimensional long-time simulations of core-collapse supernovae (CCSNe) are crucial to better understand the connection between the progenitor star and the supernova remnants.
These studies have been performed using mainly two approaches: (i) a detailed 3D analysis of individual events, e.g. SN 1987A (M\"uller et al. 1991; Orlando et al. 2015, 2020), or (ii) 1D surveys of stars with different masses and initial conditions (Ugliano et al. 2012; Sukhbold et al. 2016; Ertl et al. 2020).
Here, we intend to extend the current 3D models in the fashion of the latter 1D simulations, considering SNe originated by different red super giant (RSG) progenitors with zero-age main-sequence (ZAMS) masses between 12.5M⊠ and 27M⊠.
We first study two stars with MZAMS=19.8M⊠ and MZAMS=25.5M⊠.
The first one shows an approximate spherical symmetry in the first stages of the explosion, and asymmetries start to rise only later on.
An interesting case is instead the second model: it shows a peculiar evolution, where the explosion mainly develops on one plane, and it is starting to present structures that recall supernova remnant Cassiopeia A.
This case surely requires further investigation, but having this kind of formations so early in the evolution is really promising.
CCSN simulations are a precious resource for investigating explosion mechanisms and features of the ejecta distribution.
Moreover, from the computational results it is possible to infer some observational properties that can be used to characterize a physical source and retrieve information on its progenitor star.

Poster session / 148

NEXT-100 status and prospects

Corresponding Author(s):

NEXT (Neutrino Experiment with a Xenon TPC) is a double beta decay experiment located in Huesca (Spain) at the Laboratorio Subterraneo de Canfranc (LSC). It searches for the neutrino-less double beta decay (ββ0ν) of 136Xe, a lepton-number-violation process that would prove the Majorana nature of neutrinos and eventually provide handles for a measurement of the neutrino absolute mass. The latest stage of the experiment finished in summer 2021 with the decommissioning of the NEXT-White detector. NEXT-White proved the outstanding performance of the NEXT technology in terms of the energy resolution (<1% FWHM at 2.6 MeV) and the topology-based background rejection.

NEXT-White has also measured the relevant backgrounds for the ββ0ν search using both 136Xe-depleted and 136Xe-enriched xenon. The following stage of the experiment is the NEXT-100 detector, currently under construction. This large scale detector will hold ~100 kg of 136Xe with a background index below 5×10−4 counts/keV/kg/year and will perform the first competitive ββ0ν search within NEXT. As validated with NEXT-White, NEXT-100 will reach a sensitivity to the half-life of 6×10^25 y after 3 years of data taking, paving the way for future ton-scale phases. In this poster, I will present an overview of the status of the construction, screening program and sensitivity predictions for our NEXT-100 detector.

Poster session / 149

Calibrating the ANAIS-112 dark matter experiment with neutrons

Corresponding Author(s):

ANAIS (Annual modulation with NaI Scintillators) is a direct dark matter detection experiment whose goal is to confirm or refute in a model independent way the highly controversial positive annual modulation signal reported by DAMA/LIBRA collaboration for more than twenty cycles. ANAIS-112, consisting of 112.5 kg of NaI(Tl) scintillators, is presently in data taking phase at the Canfranc Underground Laboratory, in Spain, since August 2017. The dark matter interpretation of the modulation signal depends critically on a complete understanding of the detector response to nuclear recoils, which are expected to be induced via elastic scattering of dark matter particles off target nuclei in many of the models considered for such dark matter particles. It is well known that the light output from nuclear recoils is reduced with respect to electrons depositing an equivalent energy by the quenching factor, a parameter which is actually not well known for NaI(Tl) scintillators. Not only recent measurement on the quenching factor of sodium showed significantly different results, but also very few measurements on the quenching factor of iodine have been performed up to now. This magnitude is usually determined by measurements in a monoenergetic neutron beam, requiring small scintillating crystals to avoid multiple scattering. On the other hand, the study presented here relies on a different approach, aiming at the evaluation of the quenching factor by exposing directly the large ANAIS-112 crystals to neutrons from a Cf-252 source. For this purpose, detailed Monte Carlo simulations of the full experimental set-up are required, which should be checked against the experimental measurement. Comparison between measurement and simulation allows testing different quenching factor models and following a best-fit strategy. Moreover, this simulation could be also exploited to improve the ANAIS-112 event selection procedure, helping to identify nuclear recoils-dominated regions and to design an efficiency calibration procedure.

Poster session / 150

A probabilistic approach to the hierarchy problem

Corresponding Author(s):

In this work, we provide a simple model that studies the probability to obtain a given hierarchy between two scales. In particular, we work in a theory with a light SU(2)L sector and a heavy SU(2)H sector, and two scalar doublets with each one corresponding to one sector. Furthermore, both sectors can interact by means of a U(1)X. By the Coleman-Weinberg mechanism, the gauge bosons and scalars obtain different masses. We analyze the mass ratio of these sectors in order to discuss the hierarchy between them, and we define a probability associated to this hierarchy. We study different cases in which one of the sectors is fixed or both of them have free parameters, and also consider the effect of including an interaction between them. We conclude that the probability of obtaining very large hierarchies is (logarithmically) small but not negligible. In this toy model

some interesting situations are provided, for example, our result could be applied to a theory with a known low-energy sector and an additional weakly-interacting heavy dark sector.

Poster session / 151

CP violation in hadronic two-body D meson decays: a SM calculation

Corresponding Author(s):

In 2019 the LHCb experiment discovered for the first time a clear signal of direct CP violation in the charm sector, in particular in the decays of D0 mesons to π+π− and K+K−. However, the theoretical determination of the strong part of the related decay amplitudes in the SM remains uncertain, mainly due to the difficulties when dealing with charmed hadronic asymptotic states. A long-known tool for assessing such amplitudes is dispersion relations. These arise from fundamental properties of the S-matrix elements and are data driven at large . Although they are easily understood and deployed in elastic channels, they become much more complicated when inelasticities are present. In this work we extract the CP-even and odd D⟶ππ/KK amplitudes within the SM, analysed in the isospin basis and with the use of unitarity and large number-of-colours expansion, by performing global fits to the current experimental data. Moreover, we implement novel numerical methods for dispersion relations in the inelastic isospin-0 channels.

Poster session / 152

Long-lived heavy neutral leptons at the LHC: probing N_RSMEFT operators.

Corresponding Author(s):

Interest in searches for heavy neutral leptons (HNLs) at the LHC has increased considerably in the past few years. In the minimal scenario, HNLs are produced and decay via their mixing with active neutrinos in the Standard Model (SM) spectrum. However, many SM extensions with HNLs have been discussed in the literature, which sometimes change expectations for LHC sensitivities drastically. In the N_RSMEFT, one extends the SM effective field theory with operators including SM singlet fermions, which allows to study HNL phenomenology in a "model independent" way. Within the framework of N_RSMEFT, we study the sensitivity of ATLAS to HNLs for four-fermion operators with a single HNL. These operators might dominate both production and decay of HNLs, and we find that new physics scales in excess of 20 TeV could be probed at the high-luminosity LHC.

Dark matter / 96

Indirect detection of dark matter: status and perspectives

Corresponding Author(s):

Unveiling the nature of dark matter is one of the major endeavors of our century.
The search for dark matter is developed across multiple channels and with different techniques.
In particular, indirect searches aim at disentangling dark matter signals above the largely dominant astrophysical background in the flux of cosmic particles, such as charged cosmic rays and gamma rays. Limits on the dark matter parameter space, and, even more, detection of tentative signals

crucially depend on our understanding of the astrophysical background. I will discuss what are the main astrophysical ingredients of relevance for dark matter indirect detection and how they impact the current limits on dark matter particle models.
I will finally provide some prospects for future observations.

Dark matter / 97

Probing the nature of dark matter with gamma rays

Corresponding Author(s):

Dark matter / 98

Experimental status and perspectives on dark matter direct detection and latest ANAIS results

Corresponding Author(s):

Understanding the nature of the Dark Matter has shown to be one of the biggest challenges faced in the XXI century by Cosmology, Astrophysics and Particle Physics. It will require following complementary approaches. Among them, dark matter direct detection strategy has developed since the eighties of the past century, increasing strongly the detection sensitivity by introducing new detection techniques, ultra-low radioactive background techniques and powerful background rejection strategies. Experimental results are compatible with estimated backgrounds in general, but DAMA/LIBRA observation of an annual modulation in the detection rate compatible with that expected for dark matter particles from the galactic halo is one of the most puzzling results in the present particle physics scenario.
In this talk, we will review the present status of the direct detection searches of dark matter in general and, in particular, in the testing of the DAMA/LIBRA result, focusing on experiments using the same target material: sodium iodide. The talk will cover in more detail the performance and prospects of ANAIS-112 experiment, which using 112.5 kg of NaI(Tl) as target, is taking data at the Canfranc Underground Laboratory in Spain since August 2017

Astroparticle / 102

Neutrinos in cosmology and astroparticle physics

Corresponding Author(s):

Astroparticle / 101

Neutrino Experiments

Corresponding Author(s):

The combined result of a number of experiments demonstrated that neutrinos have mass and oscillate, and experimentalists have made enormous progress in measuring neutrino properties. However fundamental questions about neutrinos remain: Is the neutrino its own antiparticle? What is the absolute scale of neutrino masses? How are the three neutrino mass states ordered from lightest to heaviest (neutrino "mass ordering")? Is the CP symmetry violated in the neutrino sector? Are there sterile neutrino species in addition to the three active ones participating in the weak interactions? Current and future neutrino experiments are designed with state-of-the-art technology to provide answers to these questions.

Gravitational waves / 103

Gravitational waves: observations and mathematical aspects

Corresponding Author(s):

In this talk I will present a brief overview of the current gravitational wave detections and some of the most important consequences we can derive. I will also mention the plans for the forthcoming observation runs. In the last part of the talk I will comment on how mathematics can contribute in the field of gravitational wave astronomy, focusing on formulations of General Relativity, numerical simulations and data analysis.

Cosmology / 104

Early Universe Cosmology: how to co-generate Dark Matter and the Baryon asymmetry

Corresponding Author(s):

Cosmology / 105

Cosmological tensions

Corresponding Author(s):

The Cosmic Microwave Background temperature and polarization anisotropy measurements have provided strong confirmation of the LCDM model of structure formation. Even if this model can explain incredibly well the observations in a vast range of scales and epochs, with the increase of the experimental sensitivity, a few interesting tensions between the cosmological probes, and anomalies in the CMB data, have emerged with different statistical significance. While some portion of these discrepancies may be due to systematic errors, their persistence across probes strongly hints at cracks in the standard LCDM cosmological scenario. I will review these tensions, showing some interesting extended cosmological scenarios that can alleviate them.

Particle Physics / 119

Constraining the absolute neutrino mass via time-of-flight measurements of the Supernovae electron neutrinos with DUNE.

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Supernova (SN) explosions are the most powerful cosmic factories of all-flavors, MeV-scale, neutrinos. Their detection is of great importance not only for astrophysics, but also to shed light on neutrino properties. Since the first observation of a SN neutrino signal in the 1987, the international network of SN neutrinos observatories has been greatly expanded, in order to detect the next galactic SN explosion with much higher statistics and accuracy in the neutrino energy-time-flavor space. The Deep Underground Neutrino Experiment (DUNE) is a proposed leading-edge neutrino experiment, planning to begin operations in 2026. DUNE will have capability to extract precious information about SN neutrinos. In this contribution, I will discuss the constraints that we expect to achieve with DUNE on the absolute value of the neutrino mass, obtained by considering the time delay in the propagation of massive electron neutrinos from production in the SN environment to their detection in DUNE. Furthermore, the comparison of sensitivities achieved for the two possible neutrino mass orderings is discussed, as well as the effects due to propagation in the Earth matter.

Gravitational waves / 106

Precession in black hole binary systems: toward calibrating precessing phenomenological waveform models to numerical relativity

Corresponding Author(s):

Since 2015 the international advanced gravitational wave detector network has confidently detected tens of short transient signals, whose sources have been identified as mergers of compact objects, primarily binary systems of black holes. The main goal of this talk will be to discuss the phenomenon of precession in black hole binaries, as well as the first steps to further improve its description towards the next observational run, which will finally achieve design sensitivity for the LIGO and Virgo detectors. Binary black holes systems span a parameter space of nine intrinsic parameters: two spin vectors, the mass ratio, and two parameters associated with eccentricity. When the black hole spins are orthogonal to the orbital plane, there exists an equatorial symmetry of the spacetime that is preserved in time, and so are the spin directions and the orbital plane itself. The parameter space for these systems, referred to as non-precessing, reduces considerably. This is no longer true when the spins are misaligned with the orbital angular momentum: the spin-orbit and the spin-spin couplings induce a precessing motion of the orbital plane and spins, which breaks all the symmetries. Further, precession leads to a complex modulation of the signal which becomes hard to model due to the high dimensionality of the problem. This phenomenon can be simplified by using an approximate map between precessing signals in a non-inertial co-precessing frame and non-precessing signals. This approach is often called the "twisting-up approximation" and has typically been used in phenomenological waveform models. In this talk, we will discuss the main caveats of the approximation and the preliminary steps towards calibrating precession to numerical relativity simulations. These efforts may become essential to improve the accuracy of the current (fourth) generation of phenomenological waveform models developed in our group.

Particle Physics / 120

Extending the Reach of Leptophilic Boson Searches at DUNE and MiniBooNE with Bremsstrahlung and Resonant Production

Corresponding Author(s):

New gauge bosons coupling to leptons are simple and well-motivated extensions of the Standard-Model. We study the sensitivity to gauged L_\mu−L_e, L_e−L_\tau and L_\mu−L_\tau both with the existing beam dump mode data of MiniBooNE and with the DUNE near detector. We find that including bremsstrahlung and resonant production of Z^\prime which decays toe±andμ±final states leads to a significant improvement in existing bounds, especially for L_\mu–L_e and L_e–L_\tau for DUNE while competitive constraints can be achieved with the existing data from the MiniBooNE's beam dump run.

Gravitational waves / 107

Searching for long-duration transient gravitational waves from glitching pulsars using Convolutional Neural Networks

Corresponding Author(s):

Pulsars are spinning neutron stars which emit an electromagnetic beam. We expect pulsars to slowly decrease their rotational frequency due to the radiation emission. However, sudden increases of the rotational frequency have been observed from different pulsars. These events are called "glitches", and are followed by a relaxation phase with timescales from days to months. Gravitational-wave (GW) emission may follow these peculiar events, including long-duration transient continuous waves (tCWs) lasting hours to months. These are modeled similarly to continuous waves but are limited in time. Previous studies have searched for tCWs from glitching pulsars with matched filtering techniques and by computing a detection statistic, the F-statistic, maximized over a set of transient parameters like the duration and start time of the potential signals. This method is very sensitive, but the computational costs can easily increase when widening the frequency and spindown search bands and the duration of the potential signals.
In order to reduce computational and human effort, we present a procedure for detecting potential tCWs using Convolutional Neural Networks (CNNs). CNNs have proven to be valid networks for detecting various CW signals, but have never been tested on tCWs from glitching pulsars. For our initial configuration, we train the CNN on F-statistic "atoms", i.e. quantities computed during the matched filtering step from signal/noise data. This still constrains the frequency evolution of the signal to be CW-like, but already allows for flexible amplitude evolution and significant speed-up compared to the traditional method. In the future, we also plan to implement a second CNN with input the frequency-time maps, which in this case can search for unmodeled tCWs both in frequency and amplitude evolution, which we expect to be a further improvement to the speed and performance of the search.

Particle Physics / 122

Visible final-state kinematics in $b \to c\tau(\pi\nu_\tau, \rho\nu_\tau, \mu\bar{\nu}_\mu\nu_\tau)$ reactions

Corresponding Author(s):

In the context of lepton flavor universality violation (LFUV) studies, we study different observables related to the b⟶cτν¯τ semileptonic decays. These observables are expected to help in distinguishing between different NP scenarios. Since the τ lepton is very short-lived, we consider three subsequent τ-decay modes, two hadronic πντ and ρντ and one leptonic μν¯μντ, which have been previously studied for B¯⟶D(∗) decays. This way the differential decay width can be written in terms of visible (experimentally accessible) variables of the massive particle created in the τ decay.
There are seven different τ angular and spin asymmetries that are defined in this way and that can be extracted from experiment. In addition to these asymmetries, we study the d2Γd/(dωdcosθd), dΓd/dcosθd and dΓd/dEd distributions.
We present numerical results for the Λb⟶Λcτν¯τ semileptonic decay, which is being measured with precision at the LHCb.

Gravitational waves / 108

Interference signatures in the gravitational lensing of gravitational waves

Corresponding Author(s):

When gravitational waves propagate near massive objects, they are deflected as a result of gravitational lensing. This phenomenon is already known for electromagnetic waves, and it is expected for gravitational waves to be a promising new instrument in astrophysics. When the time delay between the different paths is comparable with the wave's period, interference and diffraction appear due to lensing, and they are imprinted in the waveform, as a "beating pattern". These effects are likely to be observed near the caustics, but the short-wave asymptotics associated with the geometrical optics approximation breaks down close to the caustic, where wave optics should be used. In this talk I will describe the crossover from wave optics to geometrical optics for the point mass lens model, where two parameters – the angular position of the source respect to the caustic, and the Fresnel number, which is the ratio between the Schwarzschild radius and the wavelength – are used to characterize the lensing effect. We obtain an interference pattern for the transmission factor, which allows us to suggest a simple formula for the onset of geometrical-optics oscillations which relates the Fresnel number with the angular position of the source in units of the Einstein angle

Particle Physics / 134

Flavour Symmetry & Neutrino Masses

Corresponding Author(s): omar.medina@ific.uv.es

An extra-dimensional extension of the standard model is presented. It displays a flavor A4 symmetry among the three generations of fermions at the high energy regime. The model offers a symmetrical origin to quark and lepton mixings in a unified framework. The neutrino masses in the model emerge at one loop in a scotogenic fashion. The minimalist set up of the model is highly predictive and includes a dark sector whose lightest particle can be identified as a dark matter candidate.

Gravitational waves / 109

Thermal gravitational wave emission from Holography in strongly-coupled theories

Corresponding Author(s):

There is a potentially detectable background of stochastic gravitational waves produced by thermal sources in the Universe. In this work, we provide the first computation of the gravitational-wave spectrum emitted by a thermal plasma in a strongly-coupled theory: strongly-coupled N=4 Super Yang Mills. Given the non-applicability of perturbative methods in strong coupling computations, we resort to gauge/string duality to obtain the shape of the spectrum. We later compare it with the analogue spectrum derived from the perturbative analysis in weakly-coupled Super Yang Mills. The convolution of both spectra with the expansion of the Universe provides the stochastic background of thermal gravitational waves that is present in the Universe. This work aims to mark the beginning in the study of the thermal emission from strongly-coupled cosmological sources, what could be relevant in the research of dark matter and other cosmological implications.

Particle Physics / 136

Dark sector searches with Na64 experiment at CERN

Corresponding Author(s):

The existence of dark sectors is an exciting possibility to explain the origin of Dark Matter (DM). In addition to gravity, DM could interact with ordinary matter through a new very weak force. This new interaction could be mediated by a new massive vector boson, called dark photon (A'). If A' exists, it could be produced through the kinetic mixing with a bremsstrahlung photon from a high-energy electron scattering in a target. A' could then decay invisibly into light DM particles, $A' \rightarrow \chi\chi$, or visibly, into e+e-. Searching for the former in events with large missing energy allows us to probe the $\gamma - A'$ mixing strength and the parameter space close to the one predicted by the relic dark matter density. Motivation for searching visible decays, has been recently enhanced by the anomaly observed in the 8Be and 4He nuclei transitions that could be explained by the existence of a 17 MeV boson also decaying into e+e-. In this talk, we present the NA64 results from the combined 2016-2018 data analysis for visible and invisible modes. The experiment resume data taking in 2021. The latest results and the future prospects will be also covered in this talk. Finally, the new NA64 muon program, exploring dark sectors weakly coupled to muons will also be presented.

Gravitational waves / 110

Parameter estimation of gravitational wave events with state-of-the-art phenomenological waveform models in the frequency and the time domain.

Corresponding Author(s):

In this talk, we present a re-analysis of different black hole merger gravitational wave events detected by the LIGO and Virgo interferometers with state-of-art phenomenological waveform models, IMR-PhenomX and IMRPhenomT, which include higher spherical harmonics and spin precession. Due to their rapid and accurate evaluation of the waveforms, but also an automatisation of our Bayesian inference runs, we test the waveform model families, the improvements in the precession treatment, non-informative priors, and different sampler settings and codes. In most of the studied events, the influence of higher modes is small, unless it is a massive event. In this case, IMRPhenomT further improves the fit to the data over IMRPhenomX owing to dropping the SPA approximation and other improvements in the waveform modeling. The prior choices also play an important role in challenging short signals.

Particle Physics / 124

Probing the interaction of the Higgs boson and the top-quark to explore the origin of the masses of elementary particles.

Corresponding Author(s): susana.cabrera@ific.uv.es

Exploring the mechanism that explains the origin of the masses of elementary particles, fermions and gauge bosons, remains one of the main objectives of the Particle Physics program of the LHC. One experimental probe consists of measuring the strength of the interaction between the Higgs boson and the Top quark, named top-Yukawa coupling, using the full dataset collected by the ATLAS experiment during the Run 2 operational period of the proton-proton collider LHC. Exhaustive studies of those processes that involve the associated production of Higgs bosons and Top quarks

carry out in the ATLAS collaboration are reviewed. In particular, the associated Higgs production with a single top quark has the potential to measure the size and the sign of the top-Yukawa coupling. The exploration of this process is challenging due to the small rate predicted by the current theory of the Standard Model. Therefore, sophisticated analysis techniques that integrate Machine Learning developments are needed. Such rare process cannot be observed even with the full LHC Run-2 statistics and indeed an observation of this signal would be a clear indication of new physics beyond the Standard Model, as it would imply deviations from the expected value of both the sign and magnitude of the top-Yukawa coupling.

Dark matter / 112

Signatures of primordial black hole dark matter at DUNE and THEIA

Corresponding Author(s):

Primordial black holes (PBHs) are potential dark matter candidates whose masses can span over many orders of magnitude. If they have masses in the 1015−1017 g range, they can emit sizeable fluxes of MeV neutrinos through evaporation via Hawking radiation. We explore the possibility of detecting light (non-)rotating PBHs with future neutrino experiments. We show that future neutrino experiments like DUNE and THEIA will be able to set constraints on PBH dark matter, thus providing complementary probes in a part of the PBH parameter space currently constrained mainly by photon data.

Dark matter / 137

Axion quality from the symmetric of SU(N)

Corresponding Author(s):

The Peccei-Quinn solution to the strong CP problem has a problematic aspect: it relies on a global U(1) symmetry which, although broken at low energy by the QCD anomaly, must be an extremely good symmetry of high-energy physics. This issue is known as the Peccei-Quinn quality problem. We propose a model where the Peccei-Quinn symmetry arises accidentally and is respected up to high-dimensional Planck-suppressed operators. The model is a SU(N) dark gauge theory with fermions in the fundamental and a scalar in the symmetric. The axion arises from the spontaneous symmetry breaking of the gauge group and the quality problem is successfully solved for large enough number of dark colors N. The model includes additional accidentally stable bound states which provide extra Dark Matter candidates beyond the axion.

Particle Physics / 125

Measurement of the quadruple-differential angular decay rates of single top quark produced in the t-channel at sqrt(s)=13 TeV

Corresponding Author(s): chitishv@ific.uv.es

The fact that the top quark's lifetime is smaller than its hadronization and depolarization timescales makes its production and decay kinematic properties an important probe of physical processes be-

yond the Standard Model (SM). The challenging analysis of the fully differential top-quark decay will probe the tWb vertex structure using single-top-quark events at a center-of-mass energy of 13 TeV at the LHC, using the full Run 2 dataset, with the ATLAS detector. Simultaneous measurement of the five generalized W boson helicity fractions and two phases, the polarisation in three orthogonal directions of the produced top quark as well as the t-channel production cross-section will be performed. This study is exceptional as it uses a novel model-independent framework proposed in EPJ C77 (2017) 200 and a large amount of data from proton-proton collisions of an integrated luminosity 139 fb-1. After measuring the relevant physical quantities previously mentioned, it will be possible to put stringent limits to EFT complex operators of the tWb vertex. The same measurement can be performed with early Run 3 data and constrain EFT parameters at a different energy scale. Deviations from expected values would provide hints of physics beyond the SM, and furthermore, complex values could imply that the top-quark decay has a CP-violating component.

Particle Physics / 126

Design of an alpha contamination detector with high sensitivity

Corresponding Author(s):

Particle Physics' experiments are currently searching for events whose probability is extremely low, such as the neutrinoless double beta decay or dark matter candidates such as WIMPs. This is what causes the need to perform highly sensitive experiments in subterranean facilities that shield from cosmic rays and environmental radiation. However, there is a radiation which is always present, that from Radon.

The goal of my work is the design and development, simulating in the REST environment, of this alpha detector. Such a detector must be able to characterize the alpha background caused by the decay chain of 222Rn in the active volume of the detector and that of its products on the internal surfaces (especially the 210Po, whose decay period is longer than that of the rest of the isotopes of the chain). To this end, I am characterizing and studying the response of this alpha detector, which is still under development by GIFNA and whose final result will be of great interest for the experiments being carried out at the LSC facilities.

Dark matter / 113

Sensitivity of CTA to gamma-ray emission from the Perseus galaxy cluster

Corresponding Author(s):

We estimate the sensitivity of the Cherenkov Telescope Array (CTA) to detect diffuse gamma-ray emission from the Perseus galaxy cluster, both from interactions of cosmic rays (CR) with the intracluster medium, or as a product of annihilation or decay of dark matter (DM) particles in case they are weakly interactive massive particles (WIMPs). The observation of Perseus constitutes one of the Key Science Projects proposed by the CTA Consortium for the first years of operation of the CTA Observatory. In this talk, we will focus on the DM-induced component of the flux. Our DM modeling includes the substructures we expect in the main halo of Perseus, as predicted within the standard cosmological model hierarchical structure formation scenario, which will boost the annihilation signal significantly. We compute the expected CTA sensitivity using a likelihood maximization analysis including the most recent CTA instrument response functions. We also model the expected CR-induced gamma-ray flux in the cluster, and both DM- and CR-related uncertainties via nuisance parameters. We will show the sensitivity of CTA to discover, at best, diffuse gamma-rays

in galaxy clusters for the first time. Even in absence of signal, we show that CTA will allow us to provide stringent and competitive constraints on TeV DM, that will rely on state-of-the-art modeling of the cluster's DM distribution. Finally, we will discuss the optimal strategy for CTA observations of Perseus.

Particle Physics / 123

Application of a quantum algorithm to Feynman loop integrals

Corresponding Author(s):

In this talk we present a quantum algorithm application for Feynman loop integrals. We propose a proper modification of Grover's algorithm for the identification of causal singular configurations of multiloop Feynman diagrams. The quantum algorithm is implemented in two different quantum simulators, the output obtained is directly translated to causal thresholds needed for the causal representation in the loop-tree duality.

Dark matter / 114

Dark Matter search in dwarf irregular galaxies with Fermi -LAT

Corresponding Author(s):

In these talk we highlight the main results about dark matter (DM) search in dwarf irregular galaxies with the Fermi Large Area Telescope. We analyze 11 years of Fermi-LAT data corresponding to the sky regions of 7 dwarf irregular (dIrr) galaxies. DIrrs are DM dominated systems, recently proposed as interesting targets for the indirect search of DM with gamma-rays. We create a spatial template of the expected DM-induced gamma-ray signal with the CLUMPY code, to be used in the analysis of Fermi-LAT data. No significant emission is detected from any of the targets in our sample. Thus, we compute the upper limits on the DM annihilation cross-section versus mass parameter space. The strongest constraints are obtained for ⊠⊠̄ and are at the level of ⟨⊠⊠⟩ ~ 7 × 10−26cm3s−1 at ⊠⊠ ~ 6 GeV.

Dark matter / 115

Searching for dark-matter waves with pulsar polarimetry

Corresponding Author(s):

In this talk I will explain how the polarization of photons emitted by astrophysical sources might be altered as they travel through a medium of dark matter composed of ultra light axion-like particles (ALPs). I will describe a new, more robust, analysis we delevoped to search for this effect. Afterwards, I will show the resulting strong limits on the axion-photon coupling for a wide range of masses. Finally, I will comment on possible optimal targets and the potential sensitivity to axionic dark-matter in this mass range that could be achieved using pulsar polarimetry in the future.

Dark matter / 116

Dark-matter halo shapes from fits to SPARC galaxy rotation curves

Corresponding Author(s):

We fit galactic rotation curves obtained by SPARC from dark matter haloes that are not spherically symmetric, but allowed to become prolate or oblate with a higher-multipole density distribution. This is motivated by observing that the flattening of v(r)=constant is the natural Kepler law due to a filamentary rather than a spherical source, so that elongating the distribution could bring about a smaller chi squared, all other things being equal. We compare results with different dark matter profiles and extract the best fits to the ellipticity computing cosmological simulations of dark matter haloes.

[1] Bariego Quintana, Adriana; Llanes-Estrada, Felipe and Manzanilla Carretero, Óliver (2021). Dark-matter prolate halo shapes from fits to SPARC galaxy rotation curves. Proceedings of the EPS-HEP2021
(arXiv:2109.11153 [hep-ph])
[2] Llanes-Estrada, Felipe. Elongated Gravity Sources as an Analytical Limit for Flat Galaxy Rotation Curves., Universe 7 (2021) 346; 10.13140/RG.2.2.35022.41289.
[3] Allgood et al (2006). The Shape of Dark Matter Halos: Dependence on Mass, Redshift, Radius, and Formation. Monthly Notices of the Royal Astronomical Society. 367. 1781 - 1796. 10.1111/j.1365-2966.2006.10094.x.

Dark matter / 118

Shedding light on low-mass subhalo survival with numerical simulations

Corresponding Author(s):

In this work, we carry out a suite of specially-designed numerical simulations to shed further light on dark matter (DM) subhalo survival at mass scales relevant for gamma-ray DM searches, a topic subject to intense debate nowadays. Specifically, we have developed and employed an improved version of DASH, a GPU N-body code, to study the evolution of low-mass subhaloes inside a Milky Way-like halo with unprecedented accuracy. We have simulated subhaloes with varying mass, concentration, and orbital properties, and considered the effect of the gravitational potential of the Milky-Way galaxy itself. In addition to shedding light on the survival of low-mass galactic subhaloes, our results will provide detailed predictions that will aid current and future quests for the nature of DM.

Particle Physics / 127

Searches for New Physics at neutrino experiments

Corresponding Author(s): , p.coloma@uam.es

Neutrinos are the most elusive particles in the Standard Model. Despite being so abundant in the Universe, we still do not know many of their properties: how massive are they? how many neutrinos are there? is there CP violation in the leptonic sector? do they have a connection to the dark matter, or new interactions that we are unaware of? In this talk I will present an overview of neutrino phenomenology and new physics searches using current and future neutrino experiments.

Particle Physics / 130

Theoretical Aspects of Flavour Physics

Corresponding Author(s): claudia.hagedorn@ific.uv.es,

Finding the organising principle of the flavour sector is one of the big challenges in particle physics:
a) why are there three generations of fermions?
b) why is the up quark about 100,000 times lighter than the top quark, although they have the same gauge quantum numbers?
c) why do the three generations of quarks hardly mix, whereas the three lepton generations have large mixing?
d) could there be more than three generations?
e) how many neutrinos are there?
f) could there be also more generations of Higgs particles?
In this talk, different theoretical ideas and possible experimental tests will be discussed.

Particle Physics / 128

Experimental Particle Physics with the ATLAS Detector

Corresponding Author(s):

One of the goals of particle physics is to explain the structure of matter at the smallest distance scales. For decades, the properties of the basic building blocks of matter have been investigated in ever greater detail. However, even today some profound but simple questions, such as the origins of dark matter in the universe, remain unanswered. The attempt to understand the material world around us in the simplest possible terms has involved ingenious feats of scientific sleuthing. Such fundamental questions are being addressed by using the ATLAS experiment to look at the high-energy collisions produced at the CERN Large Hadron Collider. These energetic collisions provide, for a brief instant, the energy necessary to produce new forms of matter, as was done a fraction of a second after the big bang. This presentation will illustrate how we use a very large-scale collider to probe the incredibly small, which can provide answers to questions on a universal scale!

Short bio:

Manuella Vincter is a Canada Research Professor of Physics at Carleton University and a Fellow of the Royal Society of Canada. Her primary research focus is with the ATLAS experiment at the CERN Laboratory in Geneva, Switzerland where she is the ATLAS Deputy Spokesperson. ATLAS is one of the defining experiments of its generation; its results help elucidate such fundamental questions of physics as the origins of mass and the existence of dark matter in the universe.

Particle Physics / 129

Discovering the Compact Muon Solenoid Experiment at CERN

Corresponding Author(s): balvarez@cern.ch

Discovering the Compact Muon Solenoid Experiment at CERN
Would you like to know what we do at the European Organization for Nuclear Research with proton collisions?
Learn about amazing physics driven by high level physicists from all over the world.

Discover a huge breadth of research topics, from the discovery of the Higgs boson to searches of the unknown.

Particle Physics / 131

Flavourful footprints towards TeV scale Physics

Corresponding Author(s):

In the last few years flavor experiments have been reporting deviations with respect to the expected predictions from the Standard Model. These anomalies share some patterns of lepton flavor universality violation and seem to suggest new physics at the (hopeful) TeV scale. Many attempts have been already pursued in our community trying to understand these signals, employing from any sort of simplified model to magnificent model building with a wide range of extra matter fields and gauge symmetries. In this talk we will consider a simple extension of the Standard Model based on the Pati-Salam's idea of quark-lepton unification. This economical and motivated theory turns out to predict the needed ingredients to accommodate such potential new physics and can be naturally realized at the low scale. As a renormalizable completion of the Standard Model, it predicts non-trivial signatures and correlations amongst observables that may allow its testability in a not-too-distant future.

Particle Physics / 132

Experimental Particle Physics (LHCb)

Corresponding Author(s):

Particle Physics / 133

Axion and ALP landscape

Corresponding Author(s):

Writing and speaking skills / 79

Science in the YouTube Ecosystem: Tips for Beginners

Corresponding Author(s):

Poster session / 140

Upgrade of ASACUSA's Antihydrogen Detector

Corresponding Author(s):

The goal of the ASACUSA (Atomic Spectroscopy And Collisions Using Slow Antiprotons) experiment at CERN's Antiproton Decelerator is to measure the difference of the ground state hyperfine splitting of antihydrogen and hydrogen in order to test CPT symmetry.
The ASACUSA hodoscope is an octagonal barrel-type detector consisting of plastic scintillators and read out by silicon photo multipliers (SiPMs). If the antiproton of antihydrogen annihilates in the center of the hodoscope, particles (mostly pions) are produced and travel through the various layers of the detector and produce signals.
The hodoscope was successfully used during the last data taking period at CERN. The necessary time resolution to discriminate between cosmic particles and annihilation products was previously achieved using waveform digitisers. The disadvantage of this readout scheme with digitisers is the slow readout speed, which was now improved by two orders of magnitude. This was achieved by replacing the wave form digitisers by TDCs reading out a digital time-over-threshold signal produced by the SiPM amplifier boards.
Additional scintillator tiles are under construction to also improve the tracking capabilities and position resolution of the detector. The upgraded setup is currently under test and should be installed spring 2022.

Dark matter / 117

Calibrating the ANAIS-112 dark matter experiment with neutrons

Corresponding Author(s):

ANAIS (Annual modulation with NaI Scintillators) is a direct dark matter detection experiment whose goal is to confirm or refute in a model independent way the highly controversial positive annual modulation signal reported by DAMA/LIBRA collaboration for more than twenty cycles. ANAIS-112, consisting of 112.5 kg of NaI(Tl) scintillators, is presently in data taking phase at the Canfranc Underground Laboratory, in Spain, since August 2017. The dark matter interpretation of the modulation signal depends critically on a complete understanding of the detector response to nuclear recoils, which are expected to be induced via elastic scattering of dark matter particles off target nuclei in many of the models considered for such dark matter particles. It is well known that the light output from nuclear recoils is reduced with respect to electrons depositing an equivalent energy by the quenching factor, a parameter which is actually not well known for NaI(Tl) scintillators. Not only recent measurement on the quenching factor of sodium showed significantly different results, but also very few measurements on the quenching factor of iodine have been performed up to now. This magnitude is usually determined by measurements in a monoenergetic neutron beam, requiring small scintillating crystals to avoid multiple scattering. On the other hand, the study presented here relies on a different approach, aiming at the evaluation of the quenching factor by exposing directly the large ANAIS-112 crystals to neutrons from a Cf-252 source. For this purpose, detailed Monte Carlo simulations of the full experimental set-up are required, which should be checked against the experimental measurement. Comparison between measurement and simulation allows testing different quenching factor models and following a best-fit strategy. Moreover, this simulation could be also exploited to improve the ANAIS-112 event selection procedure, helping to identify nuclear recoils-dominated regions and to design an efficiency calibration procedure.

4

Origin of heavy elements: r-process in neutron star mergers and core-collapse supernovae

Almudena Arcones[1]

[1] *TU Darmstadt and GSI*

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Our understanding of the origin of heavy elements by the r-process has made great progress in the last years. In addition to the gravitational wave and kilonova observations for GW170817, there have been major advances in the hydrodynamical simulations of neutron star mergers and core-collapse supernovae, in the microphysics included in those simulations (neutrinos and high density equation of state (EoS)), in galactic chemical evolution models, in observations of old stars in our galaxy and in dwarf galaxies. This talk will report on recent breakthroughs in understanding the extreme environment in which the formation of the heavy elements occurs, as well as open questions regarding the astrophysics and nuclear physics involved. Observations of old stars and meteorites can strongly constrain the astrophysical site of the r-process, once the nuclear physics uncertainties of extreme neutron-rich nuclei are reduced by experiments and by improved theoretical models.

Particle Physics / 121

Axion quality from the symmetric of SU(N)

Corresponding Author(s):

The Peccei-Quinn solution to the strong CP problem has a problematic aspect: it relies on a global U(1) symmetry which, although broken at low energy by the QCD anomaly, must be an extremely good symmetry of high-energy physics. This issue is known as the Peccei-Quinn quality problem. We propose a model where the Peccei-Quinn symmetry arises accidentally and is respected up to high-dimensional Planck-suppressed operators. The model is a SU(N) dark gauge theory with fermions in the fundamental and a scalar in the symmetric. The axion arises from the spontaneous symmetry breaking of the gauge group and the quality problem is successfully solved for large enough number of dark colors N. The model includes additional accidentally stable bound states which provide extra Dark Matter candidates beyond the axion.

Dark matter / 111

Dark sector searches with Na64 experiment at CERN

Corresponding Author(s):

The existence of dark sectors is an exciting possibility to explain the origin of Dark Matter (DM). In addition to gravity, DM could interact with ordinary matter through a new very weak force. This new interaction could be mediated by a new massive vector boson, called dark photon (A'). If A' exists, it could be produced through the kinetic mixing with a bremsstrahlung photon from a high-energy electron scattering in a target. A' could then decay invisibly into light DM particles, $A'\rightarrow\chi\chi$, or visibly, into e+e-. Searching for the former in events with large missing energy allows us to probe the $\gamma-A'$ mixing strength and the parameter space close to the one predicted by the relic dark matter density. Motivation for searching visible decays, has been recently enhanced by the anomaly observed in the 8Be and 4He nuclei transitions that could be explained by the existence of a 17 MeV boson also decaying into e+e-. In this talk, we present the NA64 results from the combined 2016-2018 data analysis for visible and invisible modes. The experiment resume data taking in 2021. The latest results and the future prospects will be also covered in this talk. Finally, the new NA64 muon program, exploring dark sectors weakly coupled to muons will also be presented.

Dark matter / 99

Neutrinos in cosmology and astroparticle physics

Corresponding Author(s):

Dark matter / 100

Neutrino Experiments

Corresponding Author(s):

The combined result of a number of experiments demonstrated that neutrinos have mass and oscillate, and experimentalists have made enormous progress in measuring neutrino properties. However fundamental questions about neutrinos remain: Is the neutrino its own antiparticle? What is the absolute scale of neutrino masses? How are the three neutrino mass states ordered from lightest to heaviest (neutrino "mass ordering")? Is the CP symmetry violated in the neutrino sector? Are there sterile neutrino species in addition to the three active ones participating in the weak interactions? Current and future neutrino experiments are designed with state-of-the-art technology to provide answers to these questions.

Nuclear Physics / 75

Shedding light on low-mass subhalo survival with numerical simulations

Corresponding Author(s):

In this work, we carry out a suite of specially-designed numerical simulations to shed further light on dark matter (DM) subhalo survival at mass scales relevant for gamma-ray DM searches, a topic subject to intense debate nowadays. Specifically, we have developed and employed an improved version of DASH, a GPU N-body code, to study the evolution of low-mass subhaloes inside a Milky Way-like halo with unprecedented accuracy. We have simulated subhaloes with varying mass, concentration, and orbital properties, and considered the effect of the gravitational potential of the Milky-Way galaxy itself. In addition to shedding light on the survival of low-mass galactic subhaloes, our results will provide detailed predictions that will aid current and future quests for the nature of DM.

Nuclear Physics / 60

Strongly interacting matter in the laboratory and stars

Corresponding Author(s): tolos@ice.csic.es

The interplay between the experimental results generated in terrestrial laboratories and the observations coming from stellar objects is of fundamental importance for offering solutions to long-standing puzzles in the physics of strongly interacting matter under extreme conditions. In this talk I will present the work I have been developing over the years regarding dense matter at finite temperature in two main fields: the properties of hadrons in a hot and dense medium, and the study of different phases of dense matter in neutron stars.

Nuclear Physics / 59

Proton resonances in meson production

Corresponding Author(s): ahblin@jlab.org

The description of the proton properties from its quark and gluon substructure is a topic which is far from being well understood. The strong force binding together the constituents behaves remarkably differently at high and low energies.
The main experimental tool to probe the proton is electron scattering off proton targets. At high energies, the electrons break up the protons and the underlying physics is well understood in terms of the theory that describes the strong force between quarks and gluons. However, at low energies the connection to the physics of the constituents becomes obscured. In the data spectrum, many resonances appear as interfering and overlapping peaks whose description is highly convoluted. In addition, many of them do not follow the usual quark-antiquark (meson) or 3-quark (baryon) frameworks, thus being dubbed as exotic resonances.
In this talk, I focus on the theoretical description of the resonant contributions to the proton structure. I also give emphasis to the exotic states, in view of the ongoing and near-future high-luminosity experiments designed for their search and improved understanding.

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Strongly interacting matter in the laboratory and stars

Laura Tolos[1]

[1] *IEEC-CSIC*

Corresponding Author(s): tolos@ice.csic.es

The interplay between the experimental results generated in terrestrial laboratories and the observations coming from stellar objects is of fundamental importance for offering solutions to long-standing puzzles in the physics of strongly interacting matter under extreme conditions. In this talk I will present the work I have been developing over the years regarding dense matter at finite temperature in two main fields: the properties of hadrons in a hot and dense medium, and the study of different phases of dense matter in neutron stars.

8

PET detectors, from benchtop to the clinics.

Andrea Gonzalez-Montoro[1]

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Positron Emission Tomography (PET) imaging constitutes the molecular imaging technique of excellence and is used to evaluate a radio-tracer uptake by an organ. To obtain PET images, patients are injected with radioisotopes that decay inside the patient body emitting a positron that subsequently annihilates with a core electron of the patient body, emitting two opposite 511 keV gamma-rays. PET detectors are optimized for the specific energy of 511 keV and their operation principle is based on opposed detectors measuring in coincidences these two emitted gamma-rays.
After complex image reconstruction processes a tomographic emission image is generated. To provide high quality images, in addition to the reconstruction process, PET detectors have to be carefully

designed and optimized. Key elements are the scintillation block, the photosensor and the readout electronics.
In this talk, the design, optimization, and implementation of these components is reviewed, starting at the laboratory level, overviewing the PET scanner assembly, and finishing with their translation into the clinics.

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Topological superconductivity and Majorana modes for quantum computation: a materials science perfective

Elsa Prada[1]

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My name is Elsa Prada and I am a theorist with 20 year experience in condensed matter physics. I am interested in systems where quantum phenomena play an important role, such as low dimensional materials and nanostructures, and the technological applications we can derive from such quantum properties. This is nowadays dubbed the field of "Quantum Technologies". During my career I have worked on a diverse range of problems within condensed matter, including quantum information and entanglement based on superconducting heterostructures; electronic, spintronic and optoelectronic properties of two-dimensional crystals such as graphene, phosphorene or transition metal dichalcogenides; and more recently theory and applications of topological insulators and superconductors.

In this talk I will focus on my work in topological superconductors based on superconducting-semiconducting nanowires. These hybrid wires are by far the most explored (both theoretically and experimentally) and the most advanced candidates to achieve topological superconductivity. I will discuss the appearance of exotic emergent quasiparticles at the edges of these wires, called Majorana bound states or Majorana modes. These quasiparticles share properties with the fundamental particle Majorana fermion, but they possess non-trivial exchange statistics that turn them into anyons, which could make them useful candidates for quantum-bits, qubits, of future topologically protected quantum computers. I will summarize the advancements of the field during the last decade and the problems we still face to unambiguously create and detect Majorana modes in condensed matter systems.

6

Theoretical Aspects of Flavour Physics

Claudia Hagedorn[None]

Corresponding Author(s):

Finding the organising principle of the flavour sector is one of the big challenges in particle physics:
a) why are there three generations of fermions?
b) why is the up quark about 100,000 times lighter than the top quark, although they have the same gauge quantum numbers?
c) why do the three generations of quarks hardly mix, whereas the three lepton generations have large mixing?
d) could there be more than three generations?
e) how many neutrinos are there?
f) could there be also more generations of Higgs particles?
In this talk, different theoretical ideas and possible experimental tests will be discussed.

5

Applications of Machine learning in Medical Physics: Risks and Benefits

JOAQUIN LOPEZ HERRAIZ[1]

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In this talk, we will present the application of machine learning techniques to address many medical physics problems such as positron range correction in PET, dose estimation in radiotherapy planning, the guidance of ultrasound acquisitions, tissue segmentation, automatic lesion detection… We will focus on the risks and potential benefits of these new techniques compared to current standard methods. A summary of the most common challenges in the implementation of these techniques and how to overcome them will be also presented. In conclusion, machine learning tools have the potential to revolutionize all the areas of physics, providing solutions beyond what is currently possible, and being so new, it is a great field for young researchers.

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Experimental status and perspectives on dark matter direct detection and latest ANAIS results

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Understanding the nature of the Dark Matter has shown to be one of the biggest challenges faced in the XXI century by Cosmology, Astrophysics and Particle Physics. It will require following complementary approaches. Among them, dark matter direct detection strategy has developed since the eighties of the past century, increasing strongly the detection sensitivity by introducing new detection techniques, ultra-low radioactive background techniques and powerful background rejection strategies. Experimental results are compatible with estimated backgrounds in general, but DAMA/LIBRA observation of an annual modulation in the detection rate compatible with that expected for dark matter particles from the galactic halo is one of the most puzzling results in the present particle physics scenario.
In this talk, we will review the present status of the direct detection searches of dark matter in general and, in particular, in the testing of the DAMA/LIBRA result, focusing on experiments using the same target material: sodium iodide. The talk will cover in more detail the performance and prospects of ANAIS-112 experiment, which using 112.5 kg of NaI(Tl) as target, is taking data at the Canfranc Underground Laboratory in Spain since August 2017.

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Neutrino Experiments

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The combined result of a number of experiments demonstrated that neutrinos have mass and oscillate, and experimentalists have made enormous progress in measuring neutrino properties. However fundamental questions about neutrinos remain: Is the neutrino its own antiparticle? What is the absolute scale of neutrino masses? How are the three neutrino mass states ordered from lightest to heaviest (neutrino "mass ordering")? Is the CP symmetry violated in the neutrino sector? Are there sterile neutrino species in addition to the three active ones participating in the weak interactions? Current and future neutrino experiments are designed with state-of-the-art technology to provide answers to these questions.

3

String theory and gender: a European experience

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In March 2013 the COST Action MP1210 *The String Theory Universe* was initiated for a duration of four years. The objectives were mainly scientific, but we were comitted to take a series of actions to address the problems that women that want to pursue a scientific career confront.
Given the huge imbalance in the area (only 15% of the Action members were women) we thought that the problems were severe and something had to be done.
In this talk I will speak about the initiatives that we took in order to make visible these problems to all of our colleagues and favour a change of perspective.
I think that our conclusions are still valid today.

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Gravitational waves: observations and mathematical aspects

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In this talk I will present a brief overview of the current gravitational wave detections and some of the most important consequences we can derive. I will also mention the plans for the forthcoming observation runs. In the last part of the talk I will comment on how mathematics can contribute in the field of gravitational wave astronomy, focusing on formulations of General Relativity, numerical simulations and data analysis.

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Advantages of Tomosynthesis for COVID-19 Detection with Artificial Intelligence

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Medical imaging has been one of the main tools employed during the COVID-19 pandemic for diagnosis and disease progression assessment. The most commonly used have been Chest X-Rays (CXR) and Computed Tomography (CT). However, CXR has a limited sensibility, while CT is more expensive, less accessible, gives more dose to the patients, and requires sanitizing the scanner after each patient acquisition. Tomosynthesis, which obtains X-rays images from a few source positions, has been proposed as a good compromise between both modalities.
The use of Artificial Intelligence (AI) tools to analyze medical images of COVID-19 patients has been proposed by many groups. It has been shown that Neural Networks (NN) can be trained to detect COVID-19 affections accurately provided enough cases are available. Nevertheless, while many public databases of CXR and CT images of COVID-19 patients have been generated worldwide, there is a lack of databases of tomosynthesis images, which makes it difficult to train a NN for this modality.
In this work we propose to use the existing CT and X-ray databases to perform realistic simulations and generate X-Ray tomosynthesis images. We made use of a database containing 200 CT images of COVID-19 patients, along with the segmentations of the lung affected region. Projections at 0^o and $\pm 15^o$ were simulated in an in-house developed, GPU-accelerated, ultrafast Monte Carlo (MC) code. Two NN were trained to detect whether each lung is affected by COVID-19 or not: the first one is defined with one input channel corresponding to the 0^o projection (which corresponds to a standard CXR), while the other one employs three input channels corresponding to 0^o and $\pm 15^o$ projections (which corresponds to a simplified tomosynthesis acquisition). Results show that the three-channel NN outperforms the one-channel NN. Despite the limited number of cases used in this work, and the reduced number of projections, the results are very promising, and motivates further research on the advantages which can be obtained with Tomosynthesis.

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Core-collapse supernovae from red super giant stars

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Supernova (SN) explosions are one of the most energetic events in the observable universe.
Given that, they are the best natural laboratories to investigate extreme physical phenomena, that otherwise would not be reproducible on Earth.
During these powerful explosions chemical elements are also produced, that go to enrich the amount of heavy elements in the interstellar medium.
Three-dimensional long-time simulations of core-collapse supernovae (CCSNe) are crucial to better understand the connection between the progenitor star and the supernova remnants.
These studies have been performed using mainly two approaches: (i) a detailed 3D analysis of individual events, e.g. SN 1987A (M\"uller et al. 1991; Orlando et al. 2015, 2020), or (ii) 1D surveys of stars with different masses and initial conditions (Ugliano et al. 2012; Sukhbold et al. 2016; Ertl et al. 2020).
Here, we intend to extend the current 3D models in the fashion of the latter 1D simulations, considering SNe originated by different red super giant (RSG) progenitors with zero-age main-sequence (ZAMS) masses between $12.5M_{\odot}$ and $27M_{\odot}$.
We first study two stars with $M_{ZAMS} = 19.8M_{\odot}$ and $M_{ZAMS} = 25.5M_{\odot}$.
The first one shows an approximate spherical symmetry in the first stages of the explosion, and asymmetries start to rise only later on.
An interesting case is instead the second model: it shows a peculiar evolution, where the explosion mainly develops on one plane, and it is starting to present structures that recall supernova remnant Cassiopeia A.
This case surely requires further investigation, but having this kind of formations so early in the evolution is really promising.
CCSN simulations are a precious resource for investigating explosion mechanisms and features of

the ejecta distribution.
Moreover, from the computational results it is possible to infer some observational properties that can be used to characterize a physical source and retrieve information on its progenitor star.

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NEXT-100 status and prospects

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NEXT (Neutrino Experiment with a Xenon TPC) is a double beta decay experiment located in Huesca (Spain) at the Laboratorio Subterraneo de Canfranc (LSC). It searches for the neutrino-less double beta decay (ββ0ν) of 136Xe, a lepton-number-violation process that would prove the Majorana nature of neutrinos and eventually provide handles for a measurement of the neutrino absolute mass. The latest stage of the experiment finished in summer 2021 with the decommissioning of the NEXT-White detector. NEXT-White proved the outstanding performance of the NEXT technology in terms of the energy resolution (<1% FWHM at 2.6 MeV) and the topology-based background rejection. NEXT-White has also measured the relevant backgrounds for the ββ0ν search using both 136Xe-depleted and 136Xe-enriched xenon. The following stage of the experiment is the NEXT-100 detector, currently under construction. This large scale detector will hold ~100 kg of 136Xe with a background index below 5×10−4 counts/keV/kg/year and will perform the first competitive ββ0ν search within NEXT. As validated with NEXT-White, NEXT-100 will reach a sensitivity to the half-life of 6×10^25 y after 3 years of data taking, paving the way for future ton-scale phases. In this poster, I will present an overview of the status of the construction, screening program and sensitivity predictions for our NEXT-100 detector.

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Study of Exotic Hidden Heavy Flavor States

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In recent years, a great experimental effort has led to the discovery of some exotic states found in the charmonium and bottomonium spectra. Some examples of such states are the $Z_c(3900)$, $Z_c(4020)$, $Z_{cs}(3985)$, $Z_b(10610)$ and $Z_b(10650)$. These states do not fit the conventional $q\bar{q}$ quark model given that they contain hidden-charm ($c\bar{c}$) or hidden-bottom ($b\bar{b}$) components, but they are also found to be charged. This implies a minimal structure of four valence quarks. Although there exist several exotic models which could describe these states, the molecular one is appealing due to the closeness of these states to the thresholds of some $D^{(*)}\bar{D}^{(*)}$ and $B^{(*)}\bar{B}^{(*)}$ channels. Within this framework and making use of $SU(3)$ light flavor symmetry, we predict the masses and widths of additional Z states which remain to be seen in the experiment.

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Cabibbo suppressed single pion production off the nucleon induced by antineutrinos

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In this work we study the $\Sigma\pi$ and $\Lambda\pi$ production off free nucleons driven by the strangeness-changing weak charged current. We calculate the total cross sections for all possible channels and estimate the flux-averaged total cross sections for experiments like MiniBooNE, SciBooNE, T2K, and Minerva. The model is based on the lowest order effective SU(3) chiral Lagrangians in the presence of an external weak charged current and contains Born and the lowest-lying decuplet resonant mechanisms that can contribute to these reaction channels. We also compare and discuss our results with others following similar and very different
approaches.

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Calibrating the ANAIS-112 dark matter experiment with neutrons

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ANAIS (Annual modulation with NaI Scintillators) is a direct dark matter detection experiment whose goal is to confirm or refute in a model independent way the highly controversial positive annual modulation signal reported by DAMA/LIBRA collaboration for more than twenty cycles. ANAIS-112, consisting of 112.5 kg of NaI(Tl) scintillators, is presently in data taking phase at the Canfranc Underground Laboratory, in Spain, since August 2017. The dark matter interpretation of the modulation signal depends critically on a complete understanding of the detector response to nuclear recoils, which are expected to be induced via elastic scattering of dark matter particles off target nuclei in many of the models considered for such dark matter particles. It is well known that the light output from nuclear recoils is reduced with respect to electrons depositing an equivalent energy by the quenching factor, a parameter which is actually not well known for NaI(Tl) scintillators. Not only recent measurement on the quenching factor of sodium showed significantly different results, but also very few measurements on the quenching factor of iodine have been performed up to now. This magnitude is usually determined by measurements in a monoenergetic neutron beam, requiring small scintillating crystals to avoid multiple scattering. On the other hand, the study presented here relies on a different approach, aiming at the evaluation of the quenching factor by exposing directly the large ANAIS-112 crystals to neutrons from a Cf-252 source. For this purpose, detailed Monte Carlo simulations of the full experimental set-up are required, which should be checked against the experimental measurement. Comparison between measurement and simulation allows testing different quenching factor models and following a best-fit strategy. Moreover, this simulation could be also exploited to improve the ANAIS-112 event selection procedure, helping to identify nuclear recoils-dominated regions and to design an efficiency calibration procedure.

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Implementation of a software defined radio (SDR) based beam current monitor for Schottky detectors in heavy ion storage rings

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With the increasing sensitivity and precision of resonant Schottky detectors, this technology becomes more valuable in the determination of masses and lifetimes of the yet unstudied nuclei inside heavy ion storage rings but also in general storage ring physics. At present, information from these detectors is gained by high-end units with software and hardware interface that are not versatile and / or not suitable for applications where scalability is indispensable. Here, software-defined radio (SDR) based data acquisition systems come in handy, mainly due to their low cost and relatively simple hardware but also due to the fact that their functionality is almost entirely software-defined/programmable. If calibrated, Schottky detectors can facilitate beam current measurements that are orders of magnitude more sensitive compared to existing DC current transformers (DDCT). In this work, we report on the implementation of an SDR-based online beam current monitor for use with Schottky detectors in heavy ion storage rings such as ESR in GSI/FAIR.

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CP violation in hadronic two-body D meson decays: a SM calculation

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In 2019 the LHCb experiment discovered for the first time a clear signal of direct CP violation in the charm sector, in particular in the decays of D^0 mesons to $\pi^+\pi^-$ and K^+K^-. However, the theoretical determination of the strong part of the related decay amplitudes in the SM remains uncertain, mainly due to the difficulties when dealing with charmed hadronic asymptotic states. A long-known tool for assessing such amplitudes is dispersion relations. These arise from fundamental properties of the S-matrix elements and are data driven at large . Although they are easily understood and deployed in elastic channels, they become much more complicated when inelasticities are present. In this work we extract the CP-even and odd $D \to \pi\pi/KK$ amplitudes within the SM, analysed in the isospin basis and with the use of unitarity and large number-of-colours expansion, by performing global fits to the current experimental data. Moreover, we implement novel numerical methods for dispersion relations in the inelastic isospin-0 channels.

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Upgrade of ASACUSA's Antihydrogen Detector

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The goal of the ASACUSA (Atomic Spectroscopy And Collisions Using Slow Antiprotons) experiment at CERN's Antiproton Decelerator is to measure the difference of the ground state hyperfine splitting of antihydrogen and hydrogen in order to test CPT symmetry.
The ASACUSA hodoscope is an octagonal barrel-type detector consisting of plastic scintillators and read out by silicon photo multipliers (SiPMs). If the antiproton of antihydrogen annihilates in the center of the hodoscope, particles (mostly pions) are produced and travel through the various layers of the detector and produce signals.
The hodoscope was successfully used during the last data taking period at CERN. The necessary time resolution to discriminate between cosmic particles and annihilation products was previously achieved using waveform digitisers. The disadvantage of this readout scheme with digitisers is the slow readout speed, which was now improved by two orders of magnitude. This was achieved by replacing the wave form digitisers by TDCs reading out a digital time-over-threshold signal produced by the SiPM amplifier boards.
Additional scintillator tiles are under construction to also improve the tracking capabilities and position resolution of the detector. The upgraded setup is currently under test and should be installed spring 2022.

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Gender socialization and the absence of women in science

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In this presentation, we analyse how gender stereotypes influence the choice of professional career. In particular, we discuss how patriarchal social conditioning implies a lower presence of women in science. We depict possible measures to achieve greater equity in an area as masculinized as the scientific one.

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A probabilistic approach to the hierarchy problem

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In this work, we provide a simple model that studies the probability to obtain a given hierarchy between two scales. In particular, we work in a theory with a light $SU(2)_L$ sector and a heavy $SU(2)_H$ sector, and two scalar doublets with each one corresponding to one sector. Furthermore, both sectors can interact by means of a $U(1)_X$. By the Coleman-Weinberg mechanism, the gauge bosons and scalars obtain different masses. We analyze the mass ratio of these sectors in order to discuss the hierarchy between them, and we define a probability associated to this hierarchy. We study different cases in which one of the sectors is fixed or both of them have free parameters, and also consider the effect of including an interaction between them. We conclude that the probability of obtaining very large hierarchies is (logarithmically) small but not negligible. In this toy model some interesting situations are provided, for example, our result could be applied to a theory with a known low-energy sector and an additional weakly-interacting heavy dark sector.

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Constraining the absolute neutrino mass via time-of-flight measurements of the Supernovae electron neutrinos with DUNE.

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Supernova (SN) explosions are the most powerful cosmic factories of all-flavors, MeV-scale, neutrinos. Their detection is of great importance not only for astrophysics, but also to shed light on neutrino properties. Since the first observation of a SN neutrino signal in the 1987, the international network of SN neutrinos observatories has been greatly expanded, in order to detect the next galactic SN explosion with much higher statistics and accuracy in the neutrino energy-time-flavor space. The Deep Underground Neutrino Experiment (DUNE) is a proposed leading-edge neutrino experiment, planning to begin operations in 2026. DUNE will have capability to extract precious information about SN neutrinos. In this contribution, I will discuss the constraints that we expect to achieve with DUNE on the absolute value of the neutrino mass, obtained by considering the time delay in the propagation of massive electron neutrinos from production in the SN environment to their detection in DUNE. Furthermore, the comparison of sensitivities achieved for the two possible neutrino mass orderings is discussed, as well as the effects due to propagation in the Earth matter.

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Shedding light on low-mass subhalo survival with numerical simulations

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In this work, we carry out a suite of specially-designed numerical simulations to shed further light on dark matter (DM) subhalo survival at mass scales relevant for gamma-ray DM searches, a topic subject to intense debate nowadays. Specifically, we have developed and employed an improved version of DASH, a GPU N-body code, to study the evolution of low-mass subhaloes inside a Milky Way-like halo with unprecedented accuracy. We have simulated subhaloes with varying mass, concentration, and orbital properties, and considered the effect of the gravitational potential of the Milky-Way galaxy itself. In addition to shedding light on the survival of low-mass galactic subhaloes, our results will provide detailed predictions that will aid current and future quests for the nature of DM.

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New lifetime measurements for the 2_1^+ level in $^{112,120}Sn by the Doppler-shift attenuation method

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The tin (Sn; Z = 50) isotopes constitute the longest chain of semi-magic even-even nuclei between the 100Sn (N = 50) and 132Sn (N = 82) double-shell closures, seven of which, 112,114,116,118,120,122,124Sn, are stable. These isotopes have become a prototypical benchmark of extensive microscopic theory and experiment, reflected in the large number of studies investigating the decay of their low-lying first-excited 2+ excited state. The transition characteristics are inferred through the B(E2; 0+g.s.→2+) values, which, in principle, are contingent on the lifetime of the corresponding level, and are the most direct and unambiguous test of the collective nature of the transitions.

There has been a considerable interest focused on the study of enhancement or suppression in collectivity of the excited 21+ state in the stable Sn isotopes. Independent experiments on Coulomb excitation, heavy-ion scattering and 21+ level lifetime measurements report discrepant transition probabilities, with the lifetime estimates indicating significantly reduced collectivity. A re-examination of the same has been carried out in the present work on two of the stable isotopes, 112,120Sn.

Low-lying levels in the 112,120Sn isotopes have been excited by inelastic scattering with heavy-ion beams. Level lifetime measurements have been carried out using the Doppler shift attenuation method, wherein the Doppler affected γ-ray peaks from the decay of the 21+ level in each isotope have been analyzed using updated methodologies, and corresponding B(E2; 0+g.s.→2+) values become indicative of the underlying collectivity. The present results are compared with existing estimates of the B(E2; 0+g.s.→2+) values in the stable Sn isotopes. The results are also found to be in good agreement with generalized seniority model as well as state-of-the-art Monte Carlo shell model (MCSM) calculations.

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Constraining the nuclear equation of state

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Nuclear equation of state (EOS) describes the relationship between state variables such as density, pressure and temperature of a nuclear system. It is usually expressed as the energy per nucleon of a particular nuclear medium. Constraining parameters of nuclear EOS of asymmetric nuclear matter (where asymmetry lies in proton to neutron number) is of immense importance for understanding not just the properties of neutron-rich nuclei but also for the physics of neutron stars, mergers and other astrophysical phenomena. To accomplish this goal in terrestrial laboratories one must probe observables sensitive to changes in EOS parameters of exotic unstable nuclei which were for a long time experimentally unreachable. With the advent of radioactive ion beam facilities, the region further from the valley of stability became accessible.

An experiment with the aim of constraining the symmetry-energy slope L to ± 15 MeV was held recently using large acceptance spectrometer R3B-GLAD at the GSI accelerator facility as a part of the FAIR Phase-0 campaign \cite{r3b}. Gathered data will be used to obtain total reaction, charge changing, total neutron-removal and total Coulomb-excitation cross sections along the tin isotopic chain for ^{124,128,132,134}Sn. The objective behind the choice of these measurements lies in the existence of correlation between neutron-removal and Coulomb-excitation cross sections and the respective observables familiar for having a tight connection with the parameter L: neutron-skin thickness

and the ground-state dipole polarizability \cite{tom, maza}. Stringent constraints on L will be derived from comparison of cross sections extracted from data with predictions of RMF calculations employing different energy density functionals.

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Interference signatures in the gravitational lensing of gravitational waves

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When gravitational waves propagate near massive objects, they are deflected as a result of gravitational lensing. This phenomenon is already known for electromagnetic waves, and it is expected for gravitational waves to be a promising new instrument in astrophysics. When the time delay between the different paths is comparable with the wave's period, interference and diffraction appear due to lensing, and they are imprinted in the waveform, as a "beating pattern". These effects are likely to be observed near the caustics, but the short-wave asymptotics associated with the geometrical optics approximation breaks down close to the caustic, where wave optics should be used. In this talk I will describe the crossover from wave optics to geometrical optics for the point mass lens model, where two parameters – the angular position of the source respect to the caustic, and the Fresnel number, which is the ratio between the Schwarzschild radius and the wavelength – are used to characterize the lensing effect. We obtain an interference pattern for the transmission factor, which allows us to suggest a simple formula for the onset of geometrical-optics oscillations which relates the Fresnel number with the angular position of the source in units of the Einstein angle.

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Design of an alpha contamination detector with high sensitivity

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Particle Physics' experiments are currently searching for events whose probability is extremely low, such as the neutrinoless double beta decay or dark matter candidates such as WIMPs. This is what causes the need to perform highly sensitive experiments in subterranean facilities that shield from cosmic rays and environmental radiation. However, there is a radiation which is always present, that from Radon.

The goal of my work is the design and development, simulating in the REST environment, of this alpha detector. Such a detector must be able to characterize the alpha background caused by the decay chain of ^{222}Rn in the active volume of the detector and that of its products on the internal surfaces (especially the ^{210}Po, whose decay period is longer than that of the rest of the isotopes of the chain). To this end, I am characterizing and studying the response of this alpha detector, which is

still under development by GIFNA and whose final result will be of great interest for the experiments being carried out at the LSC facilities.

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Extending the Reach of Leptophilic Boson Searches at DUNE and MiniBooNE with Bremsstrahlung and Resonant Production

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New gauge bosons coupling to leptons are simple and well-motivated extensions of the Standard-Model. We study the sensitivity to gauged $L_\mu - L_e$, $L_e - L_\tau$ and $L_\mu - L_\tau$ both with the existing beam dump mode data of MiniBooNE and with the DUNE near detector. We find that including bremsstrahlung and resonant production of Z' which decays toe±andμ±final states leads to a significant improvement in existing bounds, especially for $L_\mu - L_e$ and $L_e - L_\tau$ for DUNE while competitive constraints can be achieved with the existing data from the MiniBooNE's beam dump run.

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Boost Radiation Hardness Assurance in your Space Mission with Machine Learning

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PRECEDER (Prediction of the Electrical Behavior of Electronic Devices under Radiation, Spanish acronym) is a new concept in the strategy of ensuring the radiation hardness in electronics, developed by our group. The idea is based on the use of archival data to assess the risk associated to radiation environments without irradiation testing needs. A critical step of Radiation Hardness Assurance (RHA) for space systems is given by the parts selection in concordance with the expected radiation effects. Radiation testing is the most decisive way of studying the radiation degradation. However, the increasing use of COTS (Commercial Off-The-Shelf) devices and the New Space challenges are pushing the need of finding new approaches to assess the risk associated to the radiation environment.
PRECEDER applies the methodology of Machine Learning searching the appropriated algorithm and finding solutions quality assessment. The development of this tool includes the search for optimal usage of the accumulated data, the search for learning methods, the analysis of application features and predict the behavior of EEE (Electrical, Electronic and Electro-mechanical) devices under radiation.
In this work, the methodology and application that has been established will be shown. The first successful results, obtained for specific devices and conditions, will be presented as a practical example.

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Status of the PETALO project

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PETALO (Positron Emission TOF Apparatus with Liquid xenOn) is a new concept that seeks to demonstrate that liquid xenon (LXe) together with a SiPM-based readout and fast electronics, provide a significant improvement in the field of medical imaging with PET-TOF. Liquid xenon allows a continuous medium with a uniform response avoiding most of the geometrical distortions of conventional detectors based on scintillating crystals. PETit, the first PETALO prototype built at IFIC (Valencia), started operation in July 2021. It consists of an aluminum box with a unique volume of LXe and two planes of SiPMs that register the scintillation light emitted in xenon by the gammas coming from a Na^{22} radioactive source. After some months of data taking PETit is expected to demonstrate the potential of the technology, providing measurements of the most relevant features: reconstruction of the position, energy and time of the interactions.

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Visible final-state kinematics in $b \to c\tau(\pi\nu_\tau, \rho\nu_\tau, \mu\bar{\nu}_\mu\nu_\tau)$ reactions

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In the context of lepton flavor universality violation (LFUV) studies, we study different observables related to the $b \to c\tau\bar{\nu}_\tau$ semileptonic decays. These observables are expected to help in distinguishing between different NP scenarios. Since the τ lepton is very short-lived, we consider three subsequent τ-decay modes, two hadronic $\pi\nu_\tau$ and $\rho\nu_\tau$ and one leptonic $\mu\bar{\nu}_\mu\nu_\tau$, which have been previously studied for $\bar{B} \to D^{(*)}$ decays. This way the differential decay width can be written in terms of visible (experimentally accessible) variables of the massive particle created in the τ decay. There are seven different τ angular and spin asymmetries that are defined in this way and that can be extracted from experiment. In addition to these asymmetries, we study the $d^2\Gamma_d/(d\omega d\cos\theta_d)$, $d\Gamma_d/d\cos\theta_d$ and $d\Gamma_d/dE_d$ distributions.
We present numerical results for the $\Lambda_b \to \Lambda_c\tau\bar{\nu}_\tau$ semileptonic decay, which is being measured with precision at the LHCb.

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New ways to shed light on neutrinoless double-beta decay

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Observing neutrinoless double-beta ($0\nu\beta\beta$) is undoubtedly one of the most anticipated breakthroughs in modern-day neutrino, nuclear and particle physics. When observed, the lepton-number-violating process would provide unique vistas beyond the Standard model of particle physics. However, the expected decay rates depend on coupling constants, whose effective values are under debate, and nuclear matrix elements (NMEs) that are poorly known [1]. Hence, it is crucial to gain a better understanding of the underlying theory in order to plan future experiments and to extract the beyond-standard-model physics from them.

I will discuss how the theory predictions can be improved either directly by investigating corrections to the $0\nu\beta\beta$ decay matrix elements, or indirectly by studying related processes that can be or have been measured. First, I will introduce our recent work on a new leading-order correction to the standard $0\nu\beta\beta$-decay NMEs in heavy nuclei [2]. Then, I will discuss the relation between $0\nu\beta\beta$-decay NMEs and other nuclear observables such as two-neutrino double-beta decay, double Gamow-Teller and double-gamma transitions. In addition, I will discuss the potential of ordinary muon capture as a probe of $0\nu\beta\beta$ decay, and discuss the results of our recent muon-capture studies [3].

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Improved calculations on neutrinoless double-beta decay matrix elements

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Neutrinoless double-beta (0νββ) decay is a hypothetical nuclear process where two neutrons transmute into two protons, with only two electrons being emitted with no accompanying antineutrinos. The measurement of such a process would imply that neutrinos are Majorana particles (their own antiparticle) and, since lepton number would not be conserved, this would point to an event beyond the Standard Model of particle physics [1].

The 0νββ decay rate is governed by the nuclear matrix element [2]. Since no measurements are available for this process, we resort to methods of nuclear structure to calculate these magnitudes. In this case, our frame of work is the nuclear shell model, one of the most successful models for nuclear structure.

Using this model as our frame of work, we evaluate for the first time both the leading long-range and the newly acknowledged short-range contributions to the matrix element for the 0νββ decay of the nuclei most relevant for experiments [3].

In addition, we use shell model results to carry out, for the first time, more accurate calculations when combining them with ab initio quantum Monte Carlo results, which are able to capture additional correlations. We combine the nuclear shell model and quantum Monte Carlo approaches using the generalized contact formalism [4], and obtain improved results with respect to the standard shell model matrix elements.

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Application of a quantum algorithm to Feynman loop integrals

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In this talk we present a quantum algorithm application for Feynman loop integrals. We propose a proper modification of Grover's algorithm for the identification of causal singular configurations of multiloop Feynman diagrams. The quantum algorithm is implemented in two different quantum simulators, the output obtained is directly translated to causal thresholds needed for the causal representation in the loop-tree duality.

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Axion quality from the symmetric of SU(N)

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The Peccei-Quinn solution to the strong CP problem has a problematic aspect: it relies on a global U(1) symmetry which, although broken at low energy by the QCD anomaly, must be an extremely good symmetry of high-energy physics. This issue is known as the Peccei-Quinn quality problem. We propose a model where the Peccei-Quinn symmetry arises accidentally and is respected up to high-dimensional Planck-suppressed operators. The model is a SU(N) dark gauge theory with fermions in the fundamental and a scalar in the symmetric. The axion arises from the spontaneous symmetry breaking of the gauge group and the quality problem is successfully solved for large enough number of dark colors N. The model includes additional accidentally stable bound states which provide extra Dark Matter candidates beyond the axion.

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Forecasting hazardous Geomagnetically Induced Currents for Spanish critical infrastructures by using AI

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In the last decades, our society has become more interdependent and complex than ever before. Local impacts can cause global issues, as the current pandemic clearly shows, affecting the health of millions of human beings. It is also highly dependent on relevant technological structures, such as communications, transport, or power distribution networks, which can be very vulnerable to the effects of Space Weather. The latter has its origin in solar activity and their associated events, such as solar flares and coronal mass ejections, which may provoke disturbances, interruptions, and even long-term damage to these technical infrastructures, with drastic social, economic and even political impacts. However, these phenomena and their effects are not yet well understood, and their forecast is still in the early stages of development. This talk will present our project, which uses a multidisciplinary approach, and which aims to deeply understand and develop an early warning system to evaluate the impact of violent solar storms on Spanish critical infrastructures such as the power transmission grid, railways, and oil and gas pipelines. Specifically, we are developing an advanced machine learning based predictive model of the impact of future solar storms on the ground. This model will consist of two distinct stages. First, we are using as input real-time data from the solar wind space probe ACE (located at the L1 point in space) to develop a deep learning model taking into account past conditions to predict the variation of the magnetic field on the Earth's surface at different locations in the Iberian Peninsula. Second, we will feed these local predictions of time-variation of the magnetic field into a physical model of the 3D Earth's geoelectrical structure to generate the geoelectrical fields that drive the geomagnetically induced currents (GICs). Thus, the ultimate goal is to provide a real-time prediction of the GICs from extreme geomagnetic storms on the Spanish critical infrastructures. This talks will show our latest results and our prospects in this field.

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Searching for the nuclear Cooper pairs

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The pairing interaction induces nucleon-nucleon correlations that are essential in defining the properties of finite quantum many-body systems close to their ground states. A very specific probe of this pairing component in the nuclear interactions, which ties up nucleons in a highly correlated state, the nuclear Cooper pairs, is the two-nucleon transfer reactions. How paring correlations can be probed in heavy-ion collisions, is still an open question. Several experiments have been performed in the past, searching for signatures mainly via extraction of the enhancement coefficients, defined as the ratio of the actual transfer cross section and the prediction of the model using uncorrelated states. Unfortunately, experimental evidence of these factors is marred by the fact that all existing studies involve reactions at energies higher than the Coulomb barrier, where the reaction mechanism is the result of the interplay between nuclear and Coulomb interactions.

With the development of the new instrumentation, it nowadays became possible to measure the heavy-ion transfer reaction with high efficiency and good ion identification even at very low bombing energies where nuclei interact at large distances [1]. Multinucleon transfer reactions were measured in the ^{206}Pb + ^{118}Sn system at the INFN-LNL accelerator complex. The measurement has been

performed in the inverse kinematic, by using the heavy ^{206}Pb beam, and by detecting the lighter reaction fragments in the magnetic spectrometer PRISMA. The total cross sections of different transfer channels will be extracted in an energy range from above to well below the Coulomb barrier. By direct comparison of one- and two-nucleon transfer probabilities (one expects that the probability for the two-nucleon channel is proportional to the square of the single-particle one) we will extract the enhancement factors at the large distances. In the second stage, the experimental results will be compared with the state-of-the-art microscopical calculations which include correlations [2].

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Delving α and non-α structure beams induced incomplete fusion@ 4-7 MeV/A : A Role of Deformation

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Study of heavy-ion interactions using α and non-α structure beams at low energies [1-4] may provide a great deal of information on the in-complete fusion (ICF) reactions. In order to understand the dynamics of ICF reactions, several studies have been made and a large enhancement in cross section for α-emitting channels with respect to the calculations done with code PACE4[5] has been reported [3,7,8]. In heavy ion interactions at energies $\simeq$ 4-7 MeV/A, using both the strongly as well as weakly bound projectiles. A substantial contribution of ICF fraction has been observed [6-8]. To under the systematic behavior in the enhancement of cross section for alpha emitting channels is still an open area of investigation. In this scenario, the role of deformation of the projectile and target nuclei in observed significant contribution is not well understood. Present work is focused to study the role of deformation [9] of the target nuclides in the incomplete fusion reactions at energies of interest, using alpha and non-alpha structure beams. In order to understand the role of the target deformation in ICF, fourteen reactions have been studied using beams of 12C, 16O, and 19F with various targets e.g., 93Nb, 103Rh, 115In, 159Tb, 165Ho, 169Tm, 175Lu and 181Ta. It has been observed that the incomplete fusion fraction increasing in an exponentially manner with the deformation (β_2) of the target nucleus separately for each projectile. This systematic behavior of ICF fraction with the deformation parameter of the target nuclei has been used to develop an empirical relation. Further, analysis is in progress and results with details will be presented during the conference. The present work is supported by the Department of Science and Technology (DST), Delhi, India.

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Probing the interaction of the Higgs boson and the top-quark to explore the origin of the masses of elementary particles.

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Exploring the mechanism that explains the origin of the masses of elementary particles, fermions and gauge bosons, remains one of the main objectives of the Particle Physics program of the LHC. One experimental probe consists of measuring the strength of the interaction between the Higgs boson and the Top quark, named top-Yukawa coupling, using the full dataset collected by the ATLAS experiment during the Run 2 operational period of the proton-proton collider LHC. Exhaustive studies of those processes that involve the associated production of Higgs bosons and Top quarks carry out in the ATLAS collaboration are reviewed. In particular, the associated Higgs production with a single top quark has the potential to measure the size and the sign of the top-Yukawa coupling. The exploration of this process is challenging due to the small rate predicted by the current theory of the Standard Model. Therefore, sophisticated analysis techniques that integrate Machine Learning developments are needed. Such rare process cannot be observed even with the full LHC Run-2 statistics and indeed an observation of this signal would be a clear indication of new physics beyond the Standard Model, as it would imply deviations from the expected value of both the sign and magnitude of the top-Yukawa coupling.

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Thermal gravitational wave emission from Holography in strongly-coupled theories

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There is a potentially detectable background of stochastic gravitational waves produced by thermal sources in the Universe. In this work, we provide the first computation of the gravitational-wave spectrum emitted by a thermal plasma in a strongly-coupled theory: strongly-coupled $\mathcal{N}$=4 Super Yang Mills. Given the non-applicability of perturbative methods in strong coupling computations, we resort to gauge/string duality to obtain the shape of the spectrum. We later compare it with the analogue spectrum derived from the perturbative analysis in weakly-coupled Super Yang Mills. The convolution of both spectra with the expansion of the Universe provides the stochastic background of thermal gravitational waves that is present in the Universe. This work aims to mark the beginning in the study of the thermal emission from strongly-coupled cosmological sources, what could be relevant in the research of dark matter and other cosmological implications.

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Dark Matter search in dwarf irregular galaxies with Fermi -LAT

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In these talk we highlight the main results about dark matter (DM) search in dwarf irregular galaxies with the Fermi Large Area Telescope. We analyze 11 years of Fermi-LAT data corresponding to the sky regions of 7 dwarf irregular (dIrr) galaxies. DIrrs are DM dominated systems, recently proposed as interesting targets for the indirect search of DM with gamma-rays. We create a spatial template of the expected DM-induced gamma-ray signal with the CLUMPY code, to be used in the analysis of Fermi-LAT data. No significant emission is detected from any of the targets in our sample. Thus, we

compute the upper limits on the DM annihilation cross-section versus mass parameter space. The strongest constraints are obtained for ⊠⊠̄ and are at the level of ⟨⊠⊠⟩ ~ 7 × 10−26cm3s−1 at ⊠⊠ ~ 6 GeV.

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Nucleosynthesis in the cosmos: The ^{26}Al case

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Nucleosynthesis is an ongoing process in the cosmos which take place in various astrophysical environments such as massive stars, core-collapse supernovae or novae. One of the most famous example of evidence in the continuity of the process was the discovery of γ-ray from radioactive ^{26}Al in 1982 [1]. More recently, an all-sky map of this characteristic 1809-keV γ-ray shows a distribution of ^{26}Al in favor of massive stars and supernovae as the main progenitors [2]. Nevertheless, observational data are not enough to define precisely the source of production of ^{26}Al and 14 to 29% of the total observed ^{26}Al abundance are expected to have a nova origin [3].
In order to have a more precise picture of the different possible scenario, the ^{25}Al(p, γ)^{26}Si reaction has been studied in nuclear facilities. This reaction has a direct influence on the abundance of ^{26}Al, by bypassing the ^{25}Mg(p, γ)^{26}Al reaction responsible of the production of the ^{26}Al cosmic γ-ray emitter.

In this contribution, I'll present results which illustrate two complementary experimental domains: Mass measurement and gamma-ray spectroscopy. In ^{25}Al(p, γ)^{26}Si reaction, the proton capture is dominated by resonant capture to a few states above the proton threshold in ^{26}Si. The mass value of ^{25}Al and ^{26}Si have an exponential contribution to the total resonant proton capture rate in ^{26}Si. The mass of ^{25}Al has been precisely determined via Penning traps measurement in the IGISOL facility at the university of Jyvaskyla in Finland [5]. Additionally, a recent experiment at Argonne National Laboratory in USA was performed to identify the resonant states in ^{26}Si via γ-ray spectroscopy study using the unique GRETINA+FMA setup. This experiment came in complement to a recent spectroscopy study of the ^{26}Si mirror nucleus, ^{26}Mg, where a previously unaccounted l=1 resonance in the ^{25}Al +p system was observed [5].

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Parameter estimation of gravitational wave events with state-of-the-art phenomenological waveform models in the frequency and the time domain.

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In this talk, we present a re-analysis of different black hole merger gravitational wave events detected by the LIGO and Virgo interferometers with state-of-art phenomenological waveform models, IMRPhenomX and IMRPhenomT, which include higher spherical harmonics and spin precession. Due to their rapid and accurate evaluation of the waveforms, but also an automatisation of our Bayesian inference runs, we test the waveform model families, the improvements in the precession treatment, non-informative priors, and different sampler settings and codes. In most of the studied events, the influence of higher modes is small, unless it is a massive event. In this case, IMRPhenomT further improves the fit to the data over IMRPhenomX owing to dropping the SPA approximation and other improvements in the waveform modeling. The prior choices also play an important role in challenging short signals.

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Collinear Laser Spectroscopy and Fluorescence Detection

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Collinear laser spectroscopy provides access to many nuclear properties such as isotopic shifts of the nuclear mean square charge radii, spins, nuclear magnetic moments and electric quadrupole moments. As measurements are carried out on a small time scale, this method is well suited for the investigation of isotopes far from stability.
The development of many different techniques used in collinear laser spectroscopy has led to very small line widths of measured resonances (several 10MHz [1]). As these developments are always on going, additionally to the basic method new ideas for the fluorescence detection region of collinear laser spectroscopy apparatuses are presented and discussed.

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Searching for long-duration transient gravitational waves from glitching pulsars using Convolutional Neural Networks

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Pulsars are spinning neutron stars which emit an electromagnetic beam. We expect pulsars to slowly decrease their rotational frequency due to the radiation emission. However, sudden increases of the rotational frequency have been observed from different pulsars. These events are called "glitches", and are followed by a relaxation phase with timescales from days to months. Gravitational-wave (GW) emission may follow these peculiar events, including long-duration transient continuous waves (tCWs) lasting hours to months. These are modeled similarly to continuous waves but are limited in time. Previous studies have searched for tCWs from glitching pulsars with matched filtering techniques and by computing a detection statistic, the F-statistic, maximized over a set of transient parameters like the duration and start time of the potential signals. This method is very sensitive, but the computational costs can easily increase when widening the frequency and spindown search bands and the duration of the potential signals.
In order to reduce computational and human effort, we present a procedure for detecting potential tCWs using Convolutional Neural Networks (CNNs). CNNs have proven to be valid networks for

detecting various CW signals, but have never been tested on tCWs from glitching pulsars. For our initial configuration, we train the CNN on F-statistic "atoms", i.e. quantities computed during the matched filtering step from signal/noise data. This still constrains the frequency evolution of the signal to be CW-like, but already allows for flexible amplitude evolution and significant speed-up compared to the traditional method. In the future, we also plan to implement a second CNN with input the frequency-time maps, which in this case can search for unmodeled tCWs both in frequency and amplitude evolution, which we expect to be a further improvement to the speed and performance of the search.

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Quark mass dependence of hadron resonances

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We study the dependence of hadronic resonances on the mass of quarks through the analysis of data from QCD lattice simulations form various collaborations. Using Machine Learning techniques as the LASSO algorithm we fit lattice data in order to extrapolate them to the physical point and extract the results for the quark mass dependence for exotic resonances like Ds0 and Ds1.

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High-Gradient S-band Backward Travelling Wave Accelerating Cavity experiments at IFIC.

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High gradient radiofrequency (RF) accelerating cavities are one of the main research lines in the development of compact linear accelerators. A particular focus of these structures is for medical hadron therapy applications. However, the operation of such cavities is currently limited by nonlinear electromagnetic effects that are intensified at high electric fields, such as dark currents and RF breakdowns. A new normal-conducting High Gradient S-band Backward Travelling Wave accelerating cavity for medical application (v=0.38c) was designed and constructed by the TERA Foundation in collaboration with CERN. This cavity is being tested at the IFIC High-Gradient (HG) Radio Frequency (RF) laboratory. The main goal of the tests is understanding which is the maximum achievable accelerating gradient of this new design and characterize the dark current and breakdown formation in the structure, which could limit the applicability of this technology. In this work, we present experimental measurements and simulation results characterizing the nonlinear effects of this new accelerating cavity and first conclusions about its applicability are discussed.

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Thermal resonances and chiral symmetry restoration.

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We analize the role played by the thermal $f_0(500)$ state or σ in chiral symmetry restoration and propose an alternative sector (related with the thermal $K_0^*(700)$ or κ) to study $O(4)\times U_A(1)$ restoration. The temperature corrections to the spectral properties of those states are included in order to provide a better description of the scalar susceptibilities χ_S and χ_S^κ around the transition region. We use the Linear Sigma Model to establish the relation between χ_S and the σ propagator, which is used as a benchmark to test the approach where χ_S is saturated by the $f_0(500)$ inverse self-energy. Within such saturation approach, a peak for χ_S around the chiral transition is obtained when considering the $f_0(500)$ generated as a $\pi\pi$ scattering pole within Unitarized Chiral Perturbation Theory at finite temperature. On the other hand, we show, using Ward Identities, that χ_S^κ develops a maximum above the QCD chiral transition, above which it degenerates with χ_P^K in the $O(4) \times U_A(1)$ restoration region. Such χ_S^κ peak can be described when it is saturated with the $K_0^*(700)$, which we compute in Unitarized Chiral Perturbation Theory through πK scattering at finite temperature. That approach allows us in addition to examine the χ_S^κ dependence on the light- and strange-quark masses. Finally, a comparison with the Hadron Resonance Gas is also studied in this context.

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Sensitivity of CTA to gamma-ray emission from the Perseus galaxy cluster

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We estimate the sensitivity of the Cherenkov Telescope Array (CTA) to detect diffuse gamma-ray emission from the Perseus galaxy cluster, both from interactions of cosmic rays (CR) with the intracluster medium, or as a product of annihilation or decay of dark matter (DM) particles in case they are weakly interactive massive particles (WIMPs). The observation of Perseus constitutes one of the Key Science Projects proposed by the CTA Consortium for the first years of operation of the CTA Observatory. In this talk, we will focus on the DM-induced component of the flux. Our DM modeling includes the substructures we expect in the main halo of Perseus, as predicted within the standard cosmological model hierarchical structure formation scenario, which will boost the annihilation signal significantly. We compute the expected CTA sensitivity using a likelihood maximization analysis including the most recent CTA instrument response functions. We also model the expected CR-induced gamma-ray flux in the cluster, and both DM- and CR-related uncertainties via nuisance parameters. We will show the sensitivity of CTA to discover, at best, diffuse gamma-rays in galaxy clusters for the first time. Even in absence of signal, we show that CTA will allow us to

provide stringent and competitive constraints on TeV DM, that will rely on state-of-the-art modeling of the cluster's DM distribution. Finally, we will discuss the optimal strategy for CTA observations of Perseus.

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Searching for dark-matter waves with pulsar polarimetry

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In this talk I will explain how the polarization of photons emitted by astrophysical sources might be altered as they travel through a medium of dark matter composed of ultra light axion-like particles (ALPs). I will describe a new, more robust, analysis we delevoped to search for this effect. Afterwards, I will show the resulting strong limits on the axion-photon coupling for a wide range of masses. Finally, I will comment on possible optimal targets and the potential sensitivity to axionic dark-matter in this mass range that could be achieved using pulsar polarimetry in the future.

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Measurement of the quadruple-differential angular decay rates of single top quark produced in the t-channel at $\sqrt{s}$=13 TeV

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The fact that the top quark's lifetime is smaller than its hadronization and depolarization timescales makes its production and decay kinematic properties an important probe of physical processes beyond the Standard Model (SM). The challenging analysis of the fully differential top-quark decay will probe the tWb vertex structure using single-top-quark events at a center-of-mass energy of 13 TeV at the LHC, using the full Run 2 dataset, with the ATLAS detector. Simultaneous measurement of the five generalized W boson helicity fractions and two phases, the polarisation in three orthogonal directions of the produced top quark as well as the t-channel production cross-section will be performed. This study is exceptional as it uses a novel model-independent framework proposed in EPJ C77 (2017) 200 and a large amount of data from proton-proton collisions of an integrated luminosity 139 fb-1. After measuring the relevant physical quantities previously mentioned, it will be possible to put stringent limits to EFT complex operators of the tWb vertex. The same measurement can be performed with early Run 3 data and constrain EFT parameters at a different energy scale. Deviations from expected values would provide hints of physics beyond the SM, and furthermore, complex values could imply that the top-quark decay has a CP-violating component.

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Precession in black hole binary systems: toward calibrating precessing phenomenological waveform models to numerical relativity

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Since 2015 the international advanced gravitational wave detector network has confidently detected tens of short transient signals, whose sources have been identified as mergers of compact objects, primarily binary systems of black holes. The main goal of this talk will be to discuss the phenomenon of precession in black hole binaries, as well as the first steps to further improve its description towards the next observational run, which will finally achieve design sensitivity for the LIGO and Virgo detectors. Binary black holes systems span a parameter space of nine intrinsic parameters: two spin vectors, the mass ratio, and two parameters associated with eccentricity. When the black hole spins are orthogonal to the orbital plane, there exists an equatorial symmetry of the spacetime that is preserved in time, and so are the spin directions and the orbital plane itself. The parameter space for these systems, referred to as non-precessing, reduces considerably. This is no longer true when the spins are misaligned with the orbital angular momentum: the spin-orbit and the spin-spin couplings induce a precessing motion of the orbital plane and spins, which breaks all the symmetries. Further, precession leads to a complex modulation of the signal which becomes hard to model due to the high dimensionality of the problem. This phenomenon can be simplified by using an approximate map between precessing signals in a non-inertial co-precessing frame and non-precessing signals. This approach is often called the "twisting-up approximation" and has typically been used in phenomenological waveform models. In this talk, we will discuss the main caveats of the approximation and the preliminary steps towards calibrating precession to numerical relativity simulations. These efforts may become essential to improve the accuracy of the current (fourth) generation of phenomenological waveform models developed in our group.

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Signatures of primordial black hole dark matter at DUNE and THEIA

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Primordial black holes (PBHs) are potential dark matter candidates whose masses can span over many orders of magnitude. If they have masses in the 10^{15}–10^{17} g range, they can emit sizeable fluxes of MeV neutrinos through evaporation via Hawking radiation. We explore the possibility of detecting light (non-)rotating PBHs with future neutrino experiments. We show that future neutrino experiments like DUNE and THEIA will be able to set constraints on PBH dark matter, thus providing complementary probes in a part of the PBH parameter space currently constrained mainly by photon data.

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Study of $\alpha-$transfer reactions with ^{7}Be in the context of nuclear astrophysics

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In stellar evolution, the rate of ^{12}C(α,γ)^{16}O reaction controls the C/O abundance ratio at the end of the helium burning phase, thus defining the further course of development. At stellar temperatures of around 300 keV, the cross section of ^{12}C(α,γ)^{16}O is $\sim 10^{-17}$ b, which cannot be measured using current technology. The $\alpha-$capture reaction populating the natural-parity states of the residual nuclei, is an effective indirect tool for studying these types of reactions. In this case, it corresponds to the alpha pickup by ^{12}C to populate states of ^{16}O, predominantly the 6.917 MeV state. Loosely bound stable nuclei with prominent $\alpha-$cluster structure, such as ^{6,7}Li, ^{11}B have also been used in such studies provided that these are "direct" $\alpha-$transfer and do not proceed via a compound nucleus. However, the breakup contributions from such nuclei have a significant impact on the transfer channels. Interestingly, the ^{7}Be nucleus, though having an $\alpha-$cluster structure and a lower breakup threshold of 1.58 MeV, demonstrates lower breakup contribution compared to transfer cross section. In this context, we carried out an experiment at HIE-ISOLDE, CERN, with ^{7}Be + ^{12}C at E = 5 MeV/A to study $\alpha-$transfer reactions populating states in ^{16}O, that dominantly contribute to the He-burning process. Preliminary results would be presented.