X ComHEP: Colombian Meeting on High Energy Physics

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Book of Abstracts

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Luminosity Anomaly Finder for Pixel Luminosity Telescope in Run 3 data taking

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Luminosity is a precision measurement, for the CMS experiment. During the Run 3, the uncertainty expected in the luminosity for each year is expected to be $lesssim1\%$. However, with the detector aging, some issues with the electronics readout may occur. For luminometers as PLT with redundant measurements, this issues may not affect strongly the central measurement of the luminosity, but its uncertainty. Then, it's needed an algorithm to simplify the fill validation to take into account only the "well behaved" channels in the luminosity calculation. This same algorithm could be implemented in redundant measurements to detect anomalous behaviors, and could be implemented during the online data taking.

Theory and BSM / 3

The I(2+1)HDM with Z_3 soft breaking and the three posible DM scenarios.

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Within the context of the 3-Higgs Doublet Model with two inert doublets and one active doublet, known as the I(2+1)HDM, a Z_3 soft-breaking is allowed. Due to this soft-breaking term, three possible Dark Matter (DM) scenarios are presented. The first scenario consists of one stable DM particle and a second particle that could have a long lifetime, close to the age of the universe. The second scenario features a single DM candidate plus a particle that could have contributed to the late-time electromagnetic and hadronic energy injection in nucleosynthesis. Finally, the third scenario consists of one DM candidate and a particle that can decay inside the detector.

Cosmology / 4

Gravitational Dynamics from the Most General Entropy-Area Relation

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The connection between gravity and thermodynamics provides a profound perspective on the nature of spacetime dynamics. Jacobson famously demonstrated that the Einstein field equations can be derived by assuming the Bekenstein–Hawking relation, in which the entropy is proportional to the area of local Rindler horizons, within the framework of equilibrium thermodynamics. However, when this entropy–area relation is modified, non-equilibrium thermodynamic contributions become essential. For instance, when spacetime curvature explicitly enters this relation, the resulting field equations reduce to the $f(R)$ class of modified gravity. In this work, we address the question: \emph{what are the gravitational field equations arising from the most general entropy–area relation?} Employing non-equilibrium thermodynamic formalism, we derive the corresponding field equations for an arbitrary functional dependence $S = \alpha f(A)$. As a concrete application, we examine the case of Tsallis entropy, characterized by the non-additivity parameter δ. We show that the resulting cosmological equations—comprising the two Friedmann-like equations and a new non-equilibrium constraint—constitute an overdetermined system for any value $\delta \neq 1$. The only mathematically self-consistent solution corresponds to $\delta \equiv 1$, which exactly recovers the standard ΛCDM model. Our results thus demonstrate that, contrary to previous claims based on incomplete equilibrium approaches, Tsallis cosmology does not provide a dynamically consistent alternative to standard cosmology when non-equilibrium effects are properly taken into account.

Dark Matter / **5**

Constraining Exothermic Dark Matter via Effective Theory in the PICO-60 Bubble Chamber

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The PICO collaboration operates the world's most sensitive bubble chambers for dark matter searches, setting some of the strongest constraints on spin-dependent WIMP–nucleon interactions. As the traditional WIMP parameter space becomes increasingly constrained, attention is turning toward light and exotic candidates, including fermionic and vector dark matter with absorptive (exothermic) kinematics. In our recent work, we reported the first limits on spin-dependent absorptive interactions using a non-relativistic effective field theory (NREFT) framework, extending sensitivity below 23 MeV/c² and setting world-leading bounds on spin-independent fermionic absorption. Building on this, we explore new directions involving spin-1 particles, in particular nuclear dark Compton scattering, a channel to which PICO detectors are uniquely sensitive. Together, these results underscore the versatility of bubble chambers in probing novel dark matter interaction channels and their continuing role at the forefront of low-mass dark matter searches.

Posters / **6**

Non-perturbative approach for scalar particle production in Higgs-R^2 inflation

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Gravitational particle production in cosmology is a mechanism through which particles of different natures are produced during the very early universe. It is a general mechanism that explains how the universe became populated with the particles of the Standard Model after cosmic inflation and may also account for the origin of dark matter. In this work, we study the non-perturbative production of massive scalar particles in the Higgs-R^2 inflation model, a two-field scalar inflation model within

the Einstein frame. We consider spectator scalar fields that are conformally or minimally coupled to the gravitational field through the curvature scalar R which in turn is a time-dependent function determined by the fields driving inflationary dynamics. We numerically compute the production of these particles using the Bogolyubov transformation method for each scenario, aiming to assess the spectrum of the produced particles. For both scenarios, we consider light particles with masses and large masses that exceed the Hubble scale at the end of inflation We use these numerical results to calculate the relic abundance to find out if the model is viable as a dark matter candidate.

Theory and BSM / **7**

Prueba de las desigualdades de Leggett-Garg en oscilaciones de sabor y espín de neutrinos en un campo magnético constante

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Las desigualdades de Leggett-Garg (LG), derivadas bajo la noción de realismo macroscópico (RM), son un análogo temporal de las desigualdades de Bell, y surgen a partir de nuestras intuiciones sobre el comportamiento de sistemas clásicos. Aquí, estas desigualdades se aplican en el contexto de los neutrinos en campos magnéticos, lo cual representa una buena configuración para estudiar los aspectos de la mecánica cuántica en el caso de partículas elementales relativistas. Se resolvió la ecuación de Dirac para neutrinos en presencia de un campo magnético constante, lo cual permitió obtener las probabilidades tanto para oscilaciones de sabor como de espín. Con estas probabilidades se calcularon las correlaciones temporales necesarias para evaluar las desigualdades de LG. Los resultados muestran que dichas desigualdades se violan en ambos tipos de oscilación cuando se consideran las propiedades electromagnéticas del neutrino, siendo que, para la oscilación de sabor, para algunas regiones de la distancia entre mediciones, la violación es menos pronunciada en el escenario donde se tiene un campo magnético que el caso del vacío. Para la oscilación de espín se determinó que la violación es más elevada en el caso en el que se considera nula la diferencia al cuadrado de la masa de los neutrinos.

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Agujeros Negros Súper Masivos Y Su Influencia En La Dinámica Galáctica

Authors: Brayan Felipe Herran Garzon[1]; Jossy Steban Murcia Lozano[1]

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En el centro de la mayoría de las galaxias observadas se encuentran agujeros negros supermasivos (SMBHs, por sus siglas en inglés Super Massive Black Holes), con masas que van desde millones hasta miles de millones de veces la del Sol. Su presencia y actividad influyen decisivamente en la evolución y dinámica galáctica. Estos SMBHs liberan enormes cantidades de energía por medio de procesos de acreción y la formación de chorros relativistas, los cuales interactúan con el gas interestelar y regulan la formación estelar. Estos fenómenos, conocidos como feedback de núcleos activos de galaxias (AGN), son esenciales para explicar la correlación observada entre la masa del agujero negro y las propiedades del bulbo galáctico. Desde el campo de la física de altas energías, la emisión de rayos X, rayos gamma y neutrinos provenientes de los entornos de SMBHs ofrecen una ventana para estudiar procesos extremos de acreción y aceleración de partículas en el universo. En este trabajo se realizará una revisión bibliográfica de la conexión entre agujeros negros supermasivos, la dinámica galáctica y las observaciones en altas energías, destacando cómo estos objetos juegan un papel central en la evolución cósmica y en la comprensión de la astrofísica de altas energías.

Neutrinos / **9**

Constraints on Non-Standard Neutrino Interactions from CE$\nu\mathcal{N}$S: A Statistical Study Using CONUS+ Data

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We study constraints on non-standard neutrino interactions (NSI) using recent CE$\nu\mathcal{N}$S measurements from the CONUS+ reactor experiments. A dedicated statistical analysis is performed by constructing both a χ^2 estimator and a binned Poisson likelihood, with exclusion regions derived at 90\% C.L. for the relevant NSI couplings. By combining χ^2 minimization with likelihood profiling, we obtain robust bounds on neutrino NSIs. These results provide complementary constraints to those from other neutrino scattering experiments, strengthening the global picture of possible physics beyond the Standard Model.

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CEvNS and Light Z' Mediators: An Alternative Statistical Analysis of CONUS+ CEvNS Data

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We investigate constraints on a hypothetical light gauge boson, Z', using recent CE$\nu\mathcal{N}$S measurements from the CONUS+ reactor experiment. The presence of such a Z' would induce additional neutrino-quark interactions beyond the Standard Model. To explore this possibility, we perform both a χ^2 minimization and a binned Poisson likelihood analysis. Systematic uncertainties arising from the reactor flux, background contributions, and detector efficiency are incorporated as nuisance parameters with Gaussian priors. From this procedure, we derive 90\% C.L. exclusion regions in the $(M_{Z'}, g_{Z'})$ parameter space for representative benchmark scenarios. The resulting bounds are especially stringent for light mediators with masses of a few MeV, providing complementary constraints to those obtained from other CE$\nu\mathcal{N}$S and neutrino experiments.

Theory and BSM / **11**

Probing Flipped Trinification at Colliders

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We investigate the recently proposed gauge symmetry
$SU(3)_C \otimes SU(3)_L \otimes SU(3)_R \otimes U(1)_X$,
which naturally embeds both the Left–Right symmetric model and the 3-3-1 framework as subgroups.
Within this unified setting, we introduce four families of leptons and quarks, and perform a systematic study of their contributions to gauge anomaly cancellation for a general value of the parameter β.
Our analysis identifies eight non-universal anomaly-free models with three families and four non-universal anomaly-free sets with two families.
The three-family models provide realistic extensions of the Standard Model while preserving several appealing features of the 3-3-1 scenario. In contrast, the two-family sets offer additional flexibility for constructing models with an even number of generations.
Furthermore, we present LHC bounds on the Z' mass in the specific case $\beta = -1/3$, considering all possible assignments of lepton and quark families.
These limits show a pronounced dependence on the mixing parameter θ, which governs the couplings of Standard Model fermions to the Z' boson.

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One-Loop Neutrino Mass Matrix in the Original Scotogenic Model

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We investigate the original Scotogenic model proposed by E. Ma, focusing on its radiative mechanism for neutrino mass generation. In particular, we compute the one-loop neutrino mass matrix, regularized through the cut-off method, and express the resulting masses in terms of the Yukawa couplings and scalar potential parameters. Using representative values commonly adopted in the literature, we demonstrate that the model successfully accounts for the smallness of neutrino masses while simultaneously providing viable dark matter candidates. This study extends and builds upon the progress achieved in my undergraduate thesis research.

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Structure of the quark–gluon vertex in a rotating medium at finite temperature

Author: Miguel Angel Agudelo Fonseca[1]

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Several studies in heavy-ion collisions suggest that vorticity plays a relevant role in the final observables. In this ongoing work, we address the one-loop radiative correction to the quark–gluon vertex in a rotating medium at finite temperature. The calculation is based on the quark propagator in the presence of vorticity, incorporating thermal effects through the Matsubara formalism. Preliminary results show modifications in the vertex associated with thermal vorticity, providing tools to better understand scenarios such as relativistic heavy-ion collisions or the early universe, where these properties naturally emerge.

Cosmology / **14**

Efectos del ambiente en la historia de acreción de masa y la morfología galáctica en el contexto de simulaciones cosmológicas.

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Estudios sugieren que la morfología galáctica está influenciada por su entorno. Sin embargo,la mayoría de estos trabajos se centran en el entorno galáctico inmediato, sin considerar el entorno alrededor del halo de materia oscura que las alberga.

En este trabajo se estudia la relación entre la morfología galáctica, el entorno de su halo de materia oscura y su historia de acreción de masa. Para eso, se utilizan simulaciones cosmológicas de N-cuerpos del proyecto IllustrisTNG que modelan formación y evolución galáctica. Se introduce el concepto de dominio, como medida del ambiente cosmológico de un halo de materia oscura, y se estudia la morfología de la galaxia que hospeda y la correlación entre su masa y la masa del halo de materia oscura.

Se estudia la distribución de masa en ambientes/dominios y la relación entre la masa/tamaño del ambiente con la masa del halo. Además, la correlación entre la densidad del ambiente en el que habita un halo con la masa del dominio, y la relación entre la masa del dominio del halo con la morfología de la galaxia formada a z=0. En relación con esto, se encuentra que, aunque hay una correlación entre la historia de acreción de masa del halo y el crecimiento de su dominio y la morfología de la galaxia observada a z=0, la discriminación no es robusta. Esto sugiere que la morfología final de una galaxia no solo depende de su ambiente/dominio, sino que resulta ser la combinación de muchos otros factores, no solo ambientales.

Theory and BSM / **15**

One texture zero for Dirac neutrinos in a Diagonal charged lepton basis

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An analytic and numerical systematic study of the neutrino mass matrix Mν with one texture zero in a basis where the charged leptons are diagonal, and under the assumption that neutrinos are Dirac particles, is carried through in detail. Our study is done without any approximation, first analytically and then numerically. Current neutrino oscillation data are used in our calculations. The analysis done constraints the parameter space in such a way that among the six possible one texture zero patterns, only four turn out to be favored by current neutrino oscillation data at the 3σ level. Phenomenological implications on the lepton CP violation phase and neutrino masses are explored.

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Revisiting semileptonic B decays with tensor mesons in the final state

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Revisiting semileptonic B decays with tensor mesons in the final state

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We revisit the production of tensor mesons in semileptonic B decays within the framework of the nonrelativistic quark model of Isgur-Scora-Grinstein-Wise and the QCD factorization approach (QCDF). At tree level, we obtain the branching ratios of these decays in both frameworks and analyze the contribution of each form factor. We also present de Dalitz plot for these processes and calculate the relation:

R(D$_2^*$) =
$dfracBr(B \to D_2^* \tau \nu_\tau) Br(B \to D_2^* l \nu_\tau), \quad l = e, \mu Inadition, wecomparethe$B$\to T \tau \nu_\tau$ with the adronic $B \to TM$ decays, where M denotes a pseudoescalar or vector meson.

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Study of semileptonic B decays with scalar mesons in the final state

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Study of semileptonic B decays with scalar mesons in the final state

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We investigate the semileptonic decays $B \to S \ell \nu_\ell$, where S is the p-wave scalar meson ($^3P_0$), within the framework of the nonrelativistic quark model of Isgur-Scora-Grinstein-Wise. At tree level, we obtain the branching ratios of these decays and examine the contribution of each form factor. In addition, we compare the process $B \to S \tau \nu_\tau$ with $B \to P \tau \nu_\tau$, where P denotes a pseudoscalar meson, as well as with the hadronic decays $B \to S M$, where M denotes a pseudoscalar or vector meson. Moreover, we determine the mixing angle for the physical isoscalar mesons and show the Dalitz plot for these processes.

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Lund Jet Plane based boosted taggers for the Top quark and the W boson

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This project, carried out within the ATLAS collaboration, focused on jet substructure studies using the Lund jet plane. Lund plane variables were implemented and used to train graph-based machine learning models for tagging hadronically decaying W bosons and top quarks. The performance of these taggers was systematically evaluated using different Monte Carlo event generators, with dedicated studies on the impact of kt-based cuts. These results contribute to understanding the robustness of jet tagging methods under variations in parton shower and hadronization modeling.

Dark Matter / **19**

Two dark matter candidates in a doublet-triplet Higgs model

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We studied a Standard Model (SM) extension that provides a bicomponent dark matter scenario. The scalar sector of the SM is extended by adding an inert SU(2) doublet and an inert SU(2) triplet, as well as a SU(2) triplet with hypercharge Y=1 to generate the light neutrino masses through type-II seesaw mechanism. The contribution of the two dark matter candidates to the total dark matter abundance is employed to reduce the underabundant zones in Inert Doublet and Inert Triplet models. We also considered direct and indirect detection constraints to evaluate both dark matter candidates.

LHC / **20**

Jet Image Tagging Using Deep Learning: An Ensemble Model

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Jet Classification in high-energy physics is essential for probing fundamental interactions and for searches beyond the Standard Model. In this work, we introduce the Ensemble Model (EM) combining ResNet50 and InceptionV3 architectures for jet tagging, where jets are represented as two-dimensional histograms in the (η, ϕ) plane. This ensemble approach leverages complementary feature extraction mechanisms of the constituent networks (ResNet50 and InceptionV3) to enhance classification performance.
Using the JetNet dataset, our results demonstrate that EM consistently surpasses the performance of the individual networks in both binary and multi-class classification. For binary tasks, the EM achieves testing accuracies up to 91.7% with area under the curve (AUC) values of 0.97 in distinguishing gluon jets from W boson jets, exceeding the performance of standalone ResNet50 (91.0% and 0.96) or InceptionV3 (90.1% and 0.96). In the multi-class scenario with five jet categories (gluon, light quark, top quark, W, and Z bosons) EM reaches a testing accuracy of 75.1% and an average AUC of 0.93, reflecting stable generalization under 5-fold cross-validation, compared to 72.5% and

0.92 for ResNet50, 73.7% and 0.92 for InceptionV3. These gains were confirmed by component-wise analysis, and Grad-CAM visualizations, which reveal that the ensemble integrates fine-grained local structures and broad spatial patterns more effectively than either model alone.
Beyond its application to the JetNet dataset with 2D histogram jet images, we have now adapted our system for higher-dimensional jet representations that incorporate richer information about the collision process at the LHC. This extension enables the ensemble framework to exploit detailed particle-level and event-level features, paving the way for improved classification performance in more realistic experimental settings with potential for broader applications in LHC analyses or beyond.

Theory and BSM / **21**

The standard model of particle physics as an effective theory from two non-universal U(1)'s

Authors: Yithsbey Giraldo[None]; William A Ponce[None]; Oscar Rodríguez[None]; Eduardo Rojas[None]

We study the possibility of obtaining the Standard Model (SM) of particle physics as an effective theory of a more fundamental one, whose electroweak sector includes two non-universal local U(1) gauge groups, with the chiral anomaly cancellation taking place through an interplay among families. As a result of the spontaneous symmetry breaking, a massive gauge boson Z' arises, which couples differently to the third family of fermions (by assumption, we restrict ourselves to the scenario in which the Z' couples in the same way to the first two families). Two Higgs doublets and one scalar singlet are necessary to generate the SM fermion masses and break the gauge symmetries. We show that in our model, the flavor-changing neutral currents (FCNC) of the Higgs sector are identically zero if each right-handed SM fermion is only coupled with a single Higgs doublet. This result represents a FCNC cancellation mechanism different from the usual procedure in Two-Higgs Doublet Models. The non-universal nature of our solutions Requires the presence of three right-handed neutrino fields, one for each family. Our model generates all elements of the Dirac mass matrix for quarks and leptons, which is quite non-trivial for non-universal models.

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Dark Sector Contributions to the P5'Anomaly in the B→K*μ+μ- Decay

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Experimental measurements of this decay, made by the LHCb and CMS, show a deviation from the predictions of the Standard Model. We propose that this discrepancy can be explained by the existence of a dark sector that interacts with ordinary matter through a new mediator boson Z' .

Theory and BSM / **23**

Interpreting the R(D) and R(D*) anomalies within a singlet-triplet vector leptoquark model

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The long-standing deviations observed in the ratios R(D) and R(D*), which probe lepton flavor universality in semileptonic B meson decays, have motivated extensive studies of new physics scenarios. In this work, we explore an explanation based on a singlet–triplet vector leptoquark model, featuring both U_1 and U_3 states. We perform a comprehensive fit to the most recent experimental data on R(D) and R(D*)*, including constraints from other flavor observables. Our analysis identifies regions of parameter space where the model provides a simultaneous description of the anomalies while remaining consistent with current bounds. We further discuss the complementarity of low-energy flavor measurements and direct searches at the LHC in probing this framework.

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Identificación de tipos de partículas mediante redes neuronales en datos del CERN

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En el marco de la física de altas energías, la clasificación de las vastas cantidades de partículas subatómicas producidas en colisiones como las del Gran Colisionador de Hadrones (LHC) del CERN es un desafío computacional central. Los métodos de análisis tradicionales son a menudo lentos y exigen hardware especializado, lo que limita su accesibilidad. Este proyecto de investigación en curso aborda la necesidad de un método de clasificación más accesible, explorando el potencial de las redes neuronales artificiales para la identificación de partículas con recursos computacionales estándar.

Nuestra metodología se basa en un enfoque experimental-computacional y cuantitativo. Utilizando datos abiertos del CERN, desarrollamos y entrenamos un modelo de red neuronal artificial para clasificar tipos de partículas, basándonos en sus propiedades físicas. A través de un proceso de ajuste de hiperparámetros, buscamos la arquitectura óptima que maximice la exactitud y precisión del modelo.

Los resultados preliminares, obtenidos a partir de datasets de prueba simulados, demuestran hasta el momento que el modelo perceptrón multicapa MLP logra una alta exactitud en la clasificación de partículas. La matriz de confusión muestra que los errores de clasificación son mínimos en escenarios con distribuciones de datos bien separadas. Estos hallazgos validan la viabilidad de nuestra metodología y confirman la efectividad de las redes neuronales multicapa para reconocer patrones físicos en datos simulados.

Este trabajo no solo contribuye a la optimización del análisis de datos masivos, sino que también establece un precedente para la integración de la inteligencia artificial en la investigación en física de altas energías. El proyecto sirve como un valioso caso de estudio, demostrando que es posible desarrollar soluciones eficientes con recursos estándar, fortaleciendo así la formación académica e investigativa en el semillero y sentando las bases para futuras investigaciones en el ámbito de datos abiertos del CERN.

Theory and BSM / **25**

Effects of scalar leptoquarks S_1 and R_2 on charged lepton flavor violating decays $\tau \to \ell_n \ell_n \ell_m^c$ $(\ell = e, \mu)$

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The observation of charged lepton flavor violation would be a clear signal of new physics. In this work, we study flavor-violating three-body τ decays induced by the scalar leptoquarks R_2 and S_1. We consider a parameter space constrained by the radiative processes Δa_μ and $\ell_i \to \ell_n \gamma$, focusing on flavor structures where only the top or charm quark contributes. We compute the one-loop contributions to the processes $\tau \to \ell_n \ell_n \ell_m^c$ and provide analytical expressions for the corresponding branching ratios in the R_2 and S_1 representations. We then analyze the phenomenology of these channels, comparing the roles of the top- and charm-quark sectors in the parameter space. Our results show that, within the considered scenarios, the scalar leptoquarks R_2 and S_1 can lead to sizable branching ratios consistent with the imposed coupling constraints

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Desarrollo de un detector de centelleo de bajo costo para la detección de muones atmosféricos

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El proyecto consiste en el desarrollo de un contador de centelleo sencillo y de bajo costo, basado en un microcontrolador Arduino y componentes accesibles, para la detección de muones atmosféricos provenientes de rayos cósmicos. El sistema se compone de un material centelleador plástico acoplado a un fotodetector (SiPM o PMT de bajo voltaje), cuya señal es amplificada mediante la electrónica asociada. Los pulsos son registrados en tiempo real por el Arduino y visualizados tanto en un monitor serial como en una pantalla LCD, permitiendo el conteo en unidades de cuentas por segundo (cps).

El prototipo incluirá un módulo de alimentación de bajo costo para el fotodetector, un circuito de acoplamiento óptico con aislamiento de la luz ambiental y un sistema de adquisición básico que almacene los eventos detectados. Se realizarán pruebas experimentales para evaluar la tasa de detección en diferentes entornos, así como la atenuación del flujo de muones al atravesar materiales densos (plomo, concreto, agua). Los datos serán analizados con software libre (Python/ROOT), permitiendo contrastar los resultados con predicciones teóricas del flujo de muones a nivel del suelo.

Este desarrollo busca demostrar la viabilidad de implementar instrumentación accesible en semilleros de investigación de pregrado, introduciendo a los estudiantes en técnicas de detección empleadas en física de partículas y astropartículas.

Posters / 27

Quasinormal spectra of higher dimensional regular black holes in theories with infinite curvature corrections

Author: Juan Pablo Arbelaez Montoya[1]

[1] *Universidade Federal do ABC*

We investigate the quasinormal modes of several families of higher-dimensional regular black holes arising in gravitational theories that incorporate an infinite tower of higher-curvature corrections to Einstein gravity. Our analysis focuses on how the ringdown phase of gravitational waves for such regular black holes deviates from the predictions of General Relativity. We employ the Wentzel–Kramers–Brillouin (WKB) method to calculate the quasinormal modes and to derive compact analytic expressions in the eikonal approximation. Our results contribute to understanding how possible quantum-gravity-motivated corrections and regularity conditions can manifest in gravitational-wave signals.

Theory and BSM / **28**

Spectral Boundary Conditions in 2d-CFT: Theory and Applications to Free Boson Models

Author: Armand Idarraga-Lopez[1]

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We present a comprehensive theoretical framework for spectral boundary conditions (SBC) in two-dimensional conformal field theory, with particular focus on free boson models with boundaries. Using gamma-matrix formalism, we introduce a boundary helicity operator $\beta = \gamma_5 \partial\_\sigma$ and analyze its eigenvalue spectrum to classify boundary conditions. We investigate three distinct linear homogeneous boundary conditions: $(\Pi X)|\partial M = 0$, $\partial\sigma(1\text{-}\Pi)X|\partial M = 0$, and $(\Pi X)|\partial M + \partial\sigma(1\text{-}\Pi)X|\partial M = 0$, where Π represents various projection operators (Π_+, $\Pi_+ + \Pi_0$, Π_o, Π_e). Through Laurent mode expansions and conformal transformations from the infinite strip to the upper half-plane, we derive explicit boundary conditions for the current modes j_n and $\bar{j}_n$ of the free boson theory. Our analysis reveals how different spectral boundary conditions preserve various aspects of conformal symmetry, with implications for the Virasoro algebra generators L_n and $\bar{L}_n$. We compute the corresponding boundary partition function for one of the BCs. This work provides a systematic approach to understanding boundary effects in CFTs and offers new insights into the relationship between spectral properties and conformal invariance in the presence of boundaries.

Theory and BSM / **29**

Rompimiento espontáneo de simetrías en teoría de campos

Author: Laura Fernanda Solano Llanes[1]

Co-author: Edilson Alfonso Reyes Rojas [1]

[1] *Universidad de Pamplona*

En esta presentación se abordará el concepto de simetrías globales, locales y gauge. Se discutirá el rompimiento espontaneo de una simetría gauge y su relación con el mecanismo de Higgs en teorías de campo cuántico. Este proceso implica una transición de fase donde el parámetro cuadrático adquiere valores negativos, que puede ser obtenida dinámicamente a través de extensiones supersimétricas del Modelo Estándar con la ayuda de las técnicas del grupo de renormalización.

Theory and BSM / **30**

Searching for the LFV $\gamma\gamma e\mu$ interaction at future e^-e^+ colliders

Author: Marcela Marín Ochoa[1]

[1] *UdeA*

We investigate the lepton-flavor-violating (LFV) process $e^-e^+ \to e^-e^+e\,\mu$ (with $e = e^\pm$ and $\mu = \mu^\pm$) at future circular electron–positron colliders, probing the effective $\gamma\gamma e\mu$ interaction via photon fusion. Using an Effective Field Theory (EFT) framework that respects current theoretical and experimental constraints, we identify three benchmark points (BMPs) where the signal could be observed at the Circular Electron Positron Collider (CEPC, $\sqrt{s} = 240$ GeV) and at the Future Circular Collider (FCC-ee, $\sqrt{s} = 240,\ 350$ GeV). The most favorable BMP yields a potential 5σ discovery during early running for integrated luminosities as low as $200\ \mathrm{fb}^{-1}$ (FCC-ee) and $270\ \mathrm{fb}^{-1}$ (CEPC).

Theory and BSM / **31**

Producción y Emisión de Radiación Térmica en Colisiones de Iones Pesados: Estudio del Plasma de Quarks y Gluones (QGP)

Author: LEE JOEL RIVERA GUZMAN[1]

[1] *Universidad Surcolombiana*

En esta presentación se abordará la producción y emisión de radiación térmica en colisiones de iones pesados relativistas (RHIC y LHC), destacando los métodos de medición empleados en el estudio del plasma de quarks y gluones (QGP). Se introducirán las propiedades fundamentales del QGP, un estado de la materia recreado en colisionadores que alcanza temperaturas y densidades extremas, comparables a las del universo primitivo (˜10^{-6} s después del Big Bang, con energías del orden de 100–200 MeV). La radiación térmica, emitida principalmente en forma de fotones y pares dileptónicos, constituye una sonda directa del QGP, dado que interactúa débilmente con el medio y transporta información crucial sobre su temperatura, densidad y propiedades de transporte, como la viscosidad. Mediante técnicas experimentales avanzadas y análisis de alta precisión, se ha establecido que el QGP se comporta como un fluido cuántico casi perfecto. Finalmente, se discutirán las perspectivas futuras en la mejora de los detectores y en la incorporación de efectos de campos electromagnéticos intensos y débiles, así como su impacto en la comprensión de la dinámica del QGP en condiciones extremas.

Posters / **32**

Detección Indirecta de Materia Oscura a Través de Rayos Gamma

Author: Juan Esteban Prieto Hernandez[1]

[1] *Universidad Pedagógica y Tecnológica de Colombia*

La materia oscura representa cerca del 26 % del contenido del universo, pero su naturaleza sigue siendo desconocida debido a su nula interacción electromagnética. Entre los distintos enfoques de búsqueda, la detección indirecta busca señales en los productos de aniquilación o decaimiento de partículas de materia oscura, siendo los rayos gamma uno de los canales más prometedores. El flujo diferencial esperado depende de la sección eficaz de aniquilación promedio, el espectro de fotones producido y el factor J, relacionado con la distribución de materia oscura a lo largo de la línea de visión. Observatorios como Fermi-LAT han establecido límites estrictos al analizar galaxias enanas esferoidales, mientras que el futuro Cherenkov Telescope Array (CTA) promete mejorar la sensibilidad a señales gamma. En este trabajo se revisa el marco teórico y experimental de la detección

indirecta mediante rayos gamma, destacando su potencial para revelar la composición de la materia oscura.

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Quark–Lepton Families and Irreducible Anomaly-Free Sets in Flipped Trinification

Author: Yithsbey Giraldo Usuga[1]

Co-authors: Eduardo Rojas [2]; Richard Benavides [3]

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We develop a model-independent framework to construct **quark–lepton families** in flipped trinification, $SU(3)_C \times SU(3)_L \times SU(3)_R \times U(1)_X$, for arbitrary charge embedding. The approach identifies and classifies **Irreducible Anomaly-Free Sets (IAFS)**—minimal fermion multiplet combinations that cancel, by themselves, all gauge and mixed anomalies: $[SU(3)_{L,R}]^3$, $[SU(3)_{L,R}]^2U(1)_X$, $[SU(3)_C]^2U(1)_X$, $U(1)_X^3$, and grav$^2U(1)_X$. We show how Standard-Model families arise as unions of a small number of IAFS and derive general constraints relating family replication to color, recovering well-known 331-like non-universality as a limiting case. For each IAFS we provide electroweak-viable charge assignments, discuss the scalar content needed for the sequential breaking $SU(3)_L \times SU(3)_R \times U(1)_X \to SU(2)_L \times U(1)_Y$, and outline renormalizable Yukawa structures that generate realistic quark and lepton masses (including right-handed neutrinos) while controlling exotic states. The classification maps directly onto phenomenology, predicting patterns for extra neutral currents (Z'/Z''), exotic quark/lepton charges, residual discrete symmetries, and typical flavor textures. Our results provide a modular "building-block" toolkit to engineer flipped-trinification models from **quark–lepton families** and their **irreducible anomaly-free** combinations, clarifying which embeddings remain compatible with current collider and flavor constraints.

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Diphoton Resonances and a Flavored Axion Model

Authors: Eduardo Rojas[None]; Juan Carlos Salazar Montenegro[1]; Yithsbey Giraldo[None]

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Recent results from several experimental collaborations have reported deviations from the Standard Model predictions in di-photon final tates, suggesting the presence of intermediate scalar resonances above the electroweak scale. The wide variety of such anomalies can be naturally accommodated within extensions of the Standard Model that feature an enlarged scalar sector. In particular, multi-Higgs doublet structures are well motivated in Flavored Axion Models (FAMs) proposed to explain the texture zeros of the quark mass matrices while simultaneously addressing the strong CP problem. In this work, we analyze a specific realization of a FAM and determine the scalar mass scale at which new resonances are expected to appear, based on the most theoretically motivated ranges for the vacuum expectation values and couplings of the scalar potential. Furthermore, we examine the phenomenological implications of the model, reporting flavor-changing neutral current constraints derived from semileptonic decays, together with the current experimental bounds on the axion–photon coupling from axion searches

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Hamilton–Jacobi formulation of the Proca field with gauge symmetry

Author: German Ramos[1]

Co-author: J.F. Portillo [1]

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We analyze the constraint structure of the Proca field with gauge symmetry within the framework of the Hamilton–Jacobi formalism. The complete set of Hamiltonians generating the system's dynamics is derived from Frobenius'integrability conditions, together with the corresponding characteristic equations. As generators of canonical transformations, the Hamiltonians are naturally related to the generators of the Lagrangian gauge transformations. Finally, suitable gauge conditions are imposed, and the generalized brackets are explicitly determined.

Theory and BSM / 36

Rare Higgs Decay into a Photon and a Z Boson in Radiatively-Driven Natural Supersymmetry

Author: Cristian Alexis López Alvernia[1]

Co-authors: Daniel Melo ; Edilson Reyes ; Omar Torrijo

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In this talk, We will present the results obtained by our group on the decay of the Higgs boson into a Z boson and a photon in the Standard Model up to two-loop accuracy and within the framework of Radiatively-Driven Natural Supersymmetry.

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Doce años del bosón de Higgs: Resultados experimentales desde el descubrimiento

Author: Jean Carlo Fajardo Figueroa[1]

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El 4 de julio de 2012, las colaboraciones ATLAS y CMS del LHC anunciaron el descubrimiento de una nueva partícula con una masa cercana a 125 GeV, cuyas propiedades observadas resultaban consistentes con las del bosón de Higgs del SM. Este hallazgo abrió un extenso programa experimental orientado a estudiar en detalle sus propiedades y determinar su verdadera naturaleza. Esta charla presenta una revisión de los principales resultados obtenidos en el LHC desde su descubrimiento hasta la actualidad, destacando los avances y la evolución de la caracterización de esta partícula.

Theory and BSM / 38

Cabibbo-Kobayashi-Maskawa phase from top-bottom quark mass hierarchy in fermion basis, within the standard model

Author: Jaime Besprosvany Fridzon[1]

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The class of quark-field phase redefinitions for the standard Cabibbo-Kobayashi-Maskawa phenomenological matrix, from the relevant up-bottom, top-down matrix elements to the top-bottom one, produce a phase value consistent with $\pi/2$. This value is derived from standard-model heavy-quark mass restrictions. These stem from the Yukawa and electroweak sector connections through 1) the assumed common Higgs operator, as the boson fields' discrete degrees of freedom can be equivalently represented in terms of the fermions', based on the Lorentz and gauge symmetries; 2) a parallel quantized formulation that uses chiral components, fixing the Higgs (also mass) operator vacuum expectation, as this expansion is tested by the reproduction of the W and Z masses. Resulting favored top-bottom mass hierarchy configurations render that phase value.

Cosmology / **39**

Formalismo Geometrotermodinámico Aplicado al Agujero Negro de Kiselev en Gravedad Modificada f(R,T))

Author: JUAN DAVID PLAZAS PARDO[1]

[1] *Universidad Surcolombiana*

La geometrotermodinámica (GTD), formulada en 2007 por el Dr. Hernando Quevedo, proporciona un marco geométrico para el estudio de los sistemas termodinámicos, permitiendo describir sus propiedades y transiciones de fase mediante estructuras diferenciales invariantes. Este enfoque ha sido aplicado con éxito a diversos campos de la física, mostrando correspondencias profundas entre la curvatura del espacio de equilibrio y las interacciones termodinámicas de los sistemas.

En la presente ponencia se analiza la aplicación de la geometrotermodinámica al estudio de los agujeros negros, comparando sus resultados con la termodinámica clásica desarrollada durante el siglo XX. Se examinan las transiciones de fase y las singularidades de curvatura que reflejan la presencia de interacciones termodinámicas, destacando la correspondencia entre la transición de Hawking–Page y las predicciones geométricas obtenidas dentro del formalismo GTD.

Este análisis busca evidenciar cómo la geometrotermodinámica no solo reproduce los resultados conocidos de la termodinámica de agujeros negros, sino que además ofrece una interpretación geométrica unificada que permite identificar y caracterizar de manera natural los puntos críticos y los comportamientos singulares de estos sistemas gravitacionales.

LHC / **40**

Feasibility to probe the dynamical scotogenic model at the LHC

Authors: Carlos Andres Florez Bustos[1]; Cristian Rodriguez[2]; Gustavo Ardila[2]; Maud SARAZIN[None]; Oscar Zapata[None]

[1] *Universidad de los Andes (CO)*

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We perform a feasibility study to probe dark matter (DM) production at the LHC within a $U(1)_L$ scotogenic model. The study is conducted using the Markov Chain Monte Carlo numerical method, considering the viable parameter space of the model allowed by experimental constraints such as neutrino oscillation data, the Higgs to invisible branching fraction, and DM observables. The production of scalar and fermionic DM candidates, predicted by the model, is then studied under the LHC conditions for different luminosity scenarios imposing compressed mass spectra conditions between the lightest fermion and the $\mathbb{Z}_2$ odd scalars. We studied two production mechanisms, Drell-Yan and Vector Boson Fusion. It was found that the Drell-Yan mechanism gives better detection prospects for fermionic DM masses between 150-220˜\textrm{GeV} at high luminosity scenarios.

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Axial DM with a new SU(2) symmetry

Authors: Andres Layana[1]; Carlos Alvarado[2]; César Bonilla[3]; Sana Akram[4]

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[4] *University of the Punjab*

In this work, we propose an extension to the Standard Model (SM) by adding a new $SU(2)$ gauge symmetry, which is spontaneously broken by an extended scalar sector. Under this new symmetry, the left-handed fields of the SM remain invariant, while the right-handed ones form a doublet together with a new, heavier partner. In addition, a new fermionic field S_R is introduced, which transforms nontrivially under this symmetry and provides an axial dark matter (DM) candidate whose direct detection depends on the spin of the fields involved. Along with the DM candidate, we show that this model can also generate mass terms for the SM neutrinos through dimension-5 operators.

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Exploring Neutrino Properties with an Extended Symmetry Model

Author: KIMY JOHANA AGUDELO JARAMILLO[1]

[1] *UCN*

We are investigating a theoretical model incorporating an additional symmetry to study general neutrino interactions and their properties, including mass generation. Our ongoing work employs simulations and cross-section analyses to explore event distributions sensitive to these interactions. This research aims to deepen the understanding of neutrino properties and their implications for beyond-Standard-Model physics, with potential testability in future experiments, while remaining consistent with cosmological constraints.

Dark Matter / **44**

Dark matter and primordial black holes: an overview of constraints.

Author: Diego Cancelado Medina[1]

[1] *Estudiante*

Primordial black holes (PBHs) are an attractive alternative in the absence of direct detection of dark matter particles. Unlike exotic candidates, PBHs are solutions of general relativity that could have originated in the early universe from density fluctuations. This talk will present a concise overview of the current constraints on their viability as a component of dark matter. The most relevant limits derived from quantum evaporation (Hawking radiation), gravitational microlensing, and binary mergers observed by LIGO-Virgo-KAGRA will be discussed. These results allow us to identify regions of mass space still compatible with a significant contribution from PBHs, in particular the sublunar or asteroid range. Finally, we will highlight how these constraints establish a link between cosmology and astroparticle physics, allowing us to evaluate the role of PBHs within dark matter and their connection to high-energy physics scenarios.

LHC / **45**

HL-LHC prospects for boosted VBF HH->4b at the ATLAS experiment

Author: Jose Alejandro Portela Robayo[1]

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This study presents projection results for the search of non-resonant Higgs boson pair production via vector-boson fusion (VBF) in the boosted $HH \to b\bar{b}b\bar{b}$ final state, using the upgraded ATLAS detector at the High Luminosity LHC (HL-LHC). The analysis extends the latest Run 2 results obtained with 140 fb^{-1} of proton-proton collisions at $\sqrt{s} = 13$ TeV to HL-LHC conditions at $\sqrt{s} = 14$ TeV, exploring integrated luminosities up to 3000 fb^{-1}. The boosted topology, where each Higgs boson is reconstructed as a single large-radius jet, enhances sensitivity to the quartic Higgs-vector boson coupling modifier κ_{2V}. The extrapolation employs likelihood scans under multiple systematic uncertainty scenarios reflecting expected detector and theoretical improvements. For 3000 fb^{-1}, the 68% (95%) confidence interval for κ_{2V} is expected to be [0.84, 1.19] ([0.75, 1.27]) in the baseline scenario, and [0.86, 1.17] ([0.79, 1.23]) when only statistical uncertainties are considered. Reducing background-related systematic uncertainties by a factor of four improves the 5σ sensitivity region by up to 16%. Additionally, an enhancement of the Higgs-to-$b\bar{b}$ tagging efficiency from 0.6 to 0.9 reduces the κ_{2V} interval width by approximately 20%. These results demonstrate that the boosted HH VBF channel will play a key role in probing the Higgs self-interactions and quartic couplings with unprecedented precision at the HL-LHC.

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Simulation of three flavor neutrino oscillations on a quantum processor

Authors: Carlos Andres Florez Bustos[1]; DEYWIS MORENO[None]; Mauricio Guevara[2]; Samuel Murillo Herrera[3]

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Classical simulation of neutrino oscillations faces multiple computational challenges such as simulating collective neutrino systems and incorporating complex quantum effects (correlations in neutrino-neutrino interactions, decoherence, matter effects, etc.). Quantum computing presents an alternative to overcome these challenges, because of its inherent quantum properties it can perform actual Hamiltonian evolution of quantum systems rather than emulating them. Following the circuit

designed in [1] that encodes all three PMNS parameters (\theta_12,\theta_23,\theta_13), we simulated neutrino oscillations with different L/E ranges at the Deep Undergroud Neutrino Experiment (DUNE) baseline distance of L= 1285 km on a subspace of a two-qubit Hilbert space. The circuit is composed of an array of U3 and C-NOT gates to obtain the PMNS matrix. Comparisons between IBM publicly available quantum processors (ibm_brisbane) results and classical calculations shows excellent agreement. This work highlights the potential of quantum computers for exploring the physics of neutrino oscillations.

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Exploring the $B^+ \to K^+\nu\bar{\nu}$ anomaly with a Scalar Singlet Higgs Portal

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Co-author: Jairo Alexis Lopez [2]

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The rare decay \(Bˆ+ \to Kˆ+ \nu\bar{\nu} \) offers a powerful window into physics beyond the Standard Model (SM) due to its theoretical cleanliness and sensitivity to new light invisible particles. Within the SM, this flavor-changing neutral current (FCNC) process occurs only at loop level and it is strongly suppressed by the Glashow–Iliopoulos–Maiani (GIM) mechanism. Its final state contains two neutrinos, leading to missing energy signatures in experiments that complicate event reconstruction. The Belle II collaboration recently reported a branching ratio of \((2.3 \pm 0.7) \times 10ˆ{-5} \), deviating by approximately \(2.7\sigma \) from the SM prediction of \((4.6 \pm 0.5) \times 10ˆ{-6} \).

This tension motivates the exploration of new physics scenarios capable of accounting for the excess. One compelling possibility is the Higgs portal framework, which introduces a real scalar singlet field \(S \) that is a gauge singlet under the SM and can serve as a dark matter candidate. Though \(S \) does not directly couple to SM fermions or gauge bosons, it can interact with the Higgs boson via a renormalizable portal term \(Hˆ\dagger H S \). If kinematically accessible, the decay \(Bˆ+ \to Kˆ+ S \) can contribute to the observed branching ratio and mimic the missing energy signature attributed to neutrinos.

In this talk, we will see the scalar singlet extension of the Higgs sector and analyze the contribution of the \(Bˆ+ \to Kˆ+ S \) channel to the total missing energy signal observed in \(B \) decays. We compute the relevant branching ratios as a function of the mixing angle and the scalar mass, and compare them to the Belle II experimental result. This analysis provides a minimal and testable framework to interpret current anomalies and constrain Higgs portal models using flavor observables.

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Producción de materia oscura tipo FIMP en cosmologías no estándar

Author: Santiago Julio Dávila[1]

Co-author: Oscar Zapata

[1] *Universidad de Antioquia*

Los modelos partículas de materia oscura en la que estas se producen a través del mecanismo freeze-in se conocen como Feebly Interacting Massive Particles (FIMPs), y han sido estudiadas ampliamente en el paradigma de la cosmología estándar, sin embargo, los parámetros cosmológicos pueden variarse en tanto no se alteren las mediciones, dando lugar a modelos cosmológicos no estándar. Este trabajo explora, mediante la solución numérica de la ecuación de Boltzmann para FIMPs, el espacio de parámetros de varios modelos de partículas de materia oscura en escenarios de cosmología estándar y no estándar, obteniendo los parámetros que reproducen la abundancia de reliquia de materia oscura observada.

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Effects of Wind on the Evolution and Final Fate of Stripped Helium Stars

Authors: Dandan Wei[1]; Santiago Herrera Guzmán[2]; Ylva Götberg[1]

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Stellar winds are mechanisms through which stars lose mass from their outer layers. Although the underlying physical processes are not yet fully understood, stellar winds can strongly influence stellar evolution and determine the final fate of a star. In this work, we investigate stripped helium stars, i.e., stars that have lost their hydrogen-rich envelopes due to binary interaction. Our aim is to explore how different assumptions for the wind strength affect their subsequent evolution. Current prescriptions are largely extrapolated from Wolf-Rayet stars, which are hotter and more luminous, while recent observations suggest that stripped stars may have weaker winds than previously expected. Using stellar evolution simulations, we find that varying the wind strength can lead to different types of core-collapse supernova progenitors, ranging from compact hot blue stars to extended yellowish supergiants.

Dark Matter / **50**

A Multi-component Dark Matter Interpretation of the Galactic Center GeV Excess

Author: Carlos E. Yaguna[None]

The Galactic Center GeV Excess is a persistent anomaly in gamma-ray data that could be explained by dark matter annihilations. In this talk, we explore, in a model-independent way, the possibility that this excess is a signature of a dark sector with multiple DM particles. Specifically, we present the final states and annihilation rates that best fit the current data for scenarios with 2 and 3 dark matter particles.

Theory and BSM / **51**

Testing the Quasi-Static and Sub-Horizon Approximations in Horndesky Theories

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In the framework of Horndesky theories, we evaluate the validity and consistency of the Quasi-Static and Sub-Horizon Approximations (QSA–SHA) in the study of cosmological perturbations. By applying these approximations, we determine the corresponding gravitational potentials and compare them with the results obtained from standard perturbative treatments. This analysis allows us to identify the leading 0 order $\mathcal{O}(0)$ terms that dominate the dynamics on large scales, providing the necessary conditions for accurate numerical integrations within modified gravity scenarios.

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Segmentación retiniana asistida por inteligencia artificial: redes neuronales aplicadas al diagnóstico ocular

Author: Alejandra Arciniegas[1]

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La retinopatía diabética (RD) es una de las principales causas de ceguera a nivel mundial y requiere una detección temprana precisa para evitar complicaciones irreversibles. En este contexto, el presente trabajo presenta el diseño e implementación de un sistema automatizado de apoyo diagnóstico para la RD, que combina la segmentación de imágenes de fondo de ojo mediante redes neuronales, con el uso complementario de información clínica estructurada. Para ello, se preparó un conjunto de datos clínicamente relevantes y diversos a partir de bases de imágenes de retinografía [1][2][3]; aplicando algoritmos automatizados para la selección y filtrado de datos según criterios de calidad de imagen, condiciones de iluminación y ruido. Posteriormente se implementaron arquitecturas de segmentación utilizadas en el área médica, incluyendo U-Net, Attention U-Net y U-Net++, las cuales fueron integradas en un sistema modular orientado a la clasificación de la retinopatía diabética en distintos niveles de severidad. Se realizó una evaluación comparativa del desempeño del sistema frente a segmentaciones manuales realizadas por expertos, empleando métricas estándar como: el coeficiente Dice, el área bajo la curva ROC (AUC-ROC).
Los resultados encontrados permiten identificar una segmentación precisa de alteraciones vasculares tales como microaneurismas, hemorragias retinianas y en disco óptico, lo que resalta la capacidad del modelo para detectar cambios tempranos vasculares con una alta sensibilidad. Estos hallazgos evidencian el potencial del enfoque propuesto para ser implementado como herramienta de apoyo diagnóstico en entornos clínicos reales, incluso en condiciones de baja disponibilidad de recursos y en estrategias de telemedicina.

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Probing Earth's Interior with Supernova Neutrinos under Invisible Neutrino Decay Scenarios

Author: Edwin Alexander Delgado Insuasty[1]

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Neutrinos produced in core-collapse supernovae (CCSNe) offer a valuable probe for investigating the Earth's density profile by studying how Earth's matter influences their oscillations. Nonetheless, recent studies suggest that the Earth matter effects on CCSN neutrinos are expected to be small and

difficult to observe with existing or forthcoming neutrino detectors, primarily due to the similar fluxes of (\nu_e) and (\nu_x). In this work, we explore, within the linear regime—corresponding to neutrino trajectories traversing terrestrial distances L « 1700 km—the potential role of invisible neutrino decay in improving the determination of the Earth's density profile.

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Deep Learning Models for Jet Tagging

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Jet tagging, a classification task crucial for new physics searches at the LHC, has been evolved by deep learning. This work presents a comparative study of two state-of-the-art architectures, ParticleNet (a dynamic graph neural network) and Particle Transformer (ParT), which operate on permutation-invariant particle cloud representations of jets. We present a comparative analysis across different model architectures, dataset sizes, and feature subsets to evaluate the impact of these parameter variations on model performance for this classification task. We find that comprehensive feature engineering, incorporating low-level detector information such as track displacement parameters, is the most critical factor, elevating discovery potential by over 300\% for heavy-flavor jets. The model architecture is the second decisive factor; global attention of ParT mechanism yields a significant advantage, increasing the average discovery potential by 60\% over the locally-constrained ParticleNet. The synergy between rich, physics-informed features and powerful, globally-aware architectures is therefore paramount for maximizing scientific reach in high-energy physics.

Posters / 55

Ecuación de dínamo cosmológico bajo perturbaciones cosmológicas a primer orden

Author: Juan Felipe Bravo Cardenas[1]

Co-authors: Hector Javier Hortua ; Leonardo Castañeda

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En los últimos años las simulaciones numéricas han jugado un papel muy importante como complemento a las pruebas a las cuales es sometida constantemente la Relatividad General. Un caso particular es la Relatividad Numérica, con la cual se dificultaría la comprensión de fenómenos astrofísicos como la colisión de agujeros negros. Desde la astrofísica también se puede estudiar como planetas y estrellas pueden mantener un campo magnético dado un campo magnético semilla, este problema se puede extender a campos encontrados en galaxias y en los vacíos de la estructura a gran escala del universo. Esto lleva a un fenómeno cosmológico de interés, la evolución de campos magnéticos a lo largo de la historia del universo, los cuales se han estudiado ampliamente,tanto analítica como numéricamente. Un punto importante es que los campos alivian la actual tensión de Hubble, luego su estudio desde el punto de vista de las perturbaciones cosmológicas hace que su evolución sea de gran interés, su importancia en distintas épocas del universo y cómo a través del mecanismo de dínamo estos campos se han podido mantener desde el universo temprano hasta el día de hoy. En este trabajo se pretende dar una introducción a los campos magnéticos primordiales tomando como referencia la cosmología y la Relatividad Numérica, se mostrarán las perturbaciones cosmológicas a primer orden sobre la solución espacialmente plana de Friedman-Lemaitre-Robertson-Walker (FLRW) haciendo énfasis en el formalismo 3+1 de la relatividad Numérica, esto con miras a obtener la ecuación de dínamo cosmológico desde el punto de vista de las perturbaciones para poder estudiar la evolución de los campos magnéticos primordiales y su amplificación. También se mostrarán avances en

el estudio computacional de perturbaciones cosmológicas a partir de la Relatividad Numérica y haciendo uso del software Einstein Toolkit haciendo énfasis en FLRWSolver para la solución numérica en problemas cosmológicos, esto se hace bajo la aproximación de dínamo cinemático.

Posters / **56**

Estudio de la detectabilidad de la señal cosmológica de 21 cm a partir de estimaciones de parámetros cosmológicos.

Authors: CATALINA ALZATE HENAO[1]; Germán Chaparro Molano[1]

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La línea de 21 cm del hidrógeno neutro es una de las herramientas más prometedoras para explorar el universo temprano, permite, entre muchas cosas, estudiar algunas etapas como las Edades Oscuras, el Amanecer Cósmico y la Época de Reionización (EoR). Sin embargo, su detección directa continúa siendo un desafío debido a la presencia de contaminantes astrofísicos intensos, efectos instrumentales y efectos atmosféricos.

En este trabajo se desarrolla un modelo físico–computacional simplificado de la señal global de 21 cm basado en parámetros cosmológicos y astrofísicos tomados de la literatura, el cual se emplea como referencia para generar datos simulados. Posteriormente, la señal se "esconde"dentro de un conjunto de contaminantes sintéticos y ruido instrumental, con el fin de evaluar la capacidad de recuperación de los parámetros físicos mediante técnicas de inferencia bayesiana, específicamente el muestreo MCMC.

Este enfoque permite cuantificar la eficiencia del proceso de detección bajo distintas condiciones observacionales y caracterizar los parámetros. El objetivo final es estimar la probabilidad de recuperar la señal cosmológica de 21 cm de los datos, estableciendo un marco estadístico que contribuya al diseño y análisis de futuros experimentos de baja frecuencia como EDGES (2018).

LHC / **57**

Métodos de reconstrucción de masa en estados finales con tauones

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Co-authors: Angie Catalina Parra Ovelencio [2]; Cristian Rodriguez [2]

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Búsquedas de física más allá del modelo estándar en el LHC usan de manera frecuente diversos observables para determinar la presencia de señales asociadas a la producción de nuevas partículas. Dentro de estos observables es común encontrar distribuciones de masa reconstruidas, usando las partículas que se producen en las colisiones, en las cuales se esperan encontrar discrepancias en las distribuciones y el número de eventos entre los datos observados y los procesos de fondo del modelo estándar estimados. De observarse, se espera que dichas discrepancias sean significativas, usando figuras de mérito estadístico, y concuerden con los modelos de señales hipotéticas de procesos de nueva física. En los últimos años, se han reportado algunos excesos de eventos, con significancias locales (globales) que varían entre 2 y 3 desviaciones estándar, en canales con estados finales a fermiones de tercera generación. Sin embargo, en la mayoría de los análisis, se han usado algunos métodos tradicionales para la reconstrucción de masas. En esta charla se presentará una revisión comparativa de diversos métodos de reconstrucción de masa empleados en estudios fenomenológicos, con especial enfoque en canales de estado final con tauones. Se abordarán métodos de reconstrucción de masa

convencional, masa reconstruida usando pérdida de energía transversal, la aproximación colineal, el método MMC (Missing Mass Calculator) y el uso de Boosted Regression Trees (BRT). Dependiendo del modelo de señal, el rango de masa y las características cinemáticas de las partículas de estado final, cada uno de estos métodos brinda significancias diferentes, lo cual resulta fundamental a nivel experimental.

LHC / **59**

Two-Higgs-doublet models in light of current experiments

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The Two Higgs Doublet Model (2HDM) is one of the simplest and best motivated extensions of the Standard Model (SM), which expands the scalar sector. By introducing a second Higgs doublet, it provides new sources of CP violation that are relevant for baryogenesis and potential explanations for flavor anomalies observed in B-meson decays. In this model, the Yukawa couplings scale with the fermion masses, making the tau lepton a particularly sensitive probe to search for type extension of the SM.

In this work, we present a phenomenological study of the Type II 2HDM, performing a systematic exploration of the parameter space defined by the heavy scalar masses and the mixing parameter tanβ, while remaining consistent with the SM-like behavior of the observed 125 GeV Higgs boson. We incorporate theoretical constraints along with current experimental bounds from LHC searches and B-physics observables to delineate the allowed regions in parameter space. Using Monte Carlo simulations and machine learning techniques, we identify viable configurations and evaluate the discovery potential of additional Higgs states in τ-lepton final states. Our results highlight benchmark scenarios with heavy charged and neutral scalars that remain within reach of the current LHC and the future High-Luminosity LHC program.

Neutrinos / **60**

Monte Carlo simulation of thermal neutron detection using boron-doped graphene films coupled with SiPM sensors

Author: Luis Ricardo Beltran Garcia[1]

[1] *Universidad Antonio Nariño*

Efficient neutron detection is crucial in areas such as nuclear security, medical physics, and materials research. This work presents the simulation of a thermal neutron detection system using the Geant4 toolkit. The design includes an Americium-Beryllium (AmBe) source as a neutron emitter, a paraffin block for neutron thermalization, a boron-10 enriched graphene film, a scintillating material for detection of the products of the neutron-boron interaction, and a SiPM for signal readout. The simulation will be performed in three different phases: first neutrons emitted by the AmBe source and are thermalized in the paraffin. The second phase consists of neutron capture by the boron-10, which produces lithium and alpha particles or gammas, and the third phase consists of the final detection in the scintillator-SiPM system. Preliminary results focus on system efficiency, optimization of the paraffin geometry, and signal-to-noise ratio analysis. This design demostrates the potential of graphene-boron compounds as efficient and lightweight converters for thermal neutron detection, offering valuable perspectives for the development of advanced detectors.

LHC / **61**

On the Tau Polarization Estimation in One-Prong Hadronic Decays at the LHC

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The Standard Model (SM) remains the most successful framework for describing particle interactions, yet it leaves key questions unresolved, including possible Lepton Flavor Universality (LFU) violation. Many proposed extensions of the SM predict new particles that couple preferentially to tau leptons, such as S1 and U1 leptoquarks, Z'_{B-L} bosons, and Type-II Two-Higgs-Doublet Models. Testing these scenarios requires precise reconstruction of tau polarization, a key observable for distinguishing between scalar and vector particles in both resonant and non-resonant signatures with taus in the final state.

This work focuses on improving the distributions used to estimate the likelihood of tau polarization in events with one charged-prong hadronic tau decay by refining existing maximum-likelihood techniques, such as those used by the ATLAS collaboration, through machine learning approaches —specifically Boosted Decision Trees (BDTs). These enhanced polarization estimators enable more accurate discrimination between different particle hypotheses and increase the sensitivity to new physics. Monte Carlo simulations are employed to evaluate their performance in the context of the proposed models, assessing how background effects and model-specific kinematics influence the reconstructed polarization.

Posters / **62**

Exploring the Standard Model and Its Frontiers with the CONUS+ Experiment

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Coherent elastic neutrino–nucleus scattering (CEνNS), predicted by the Standard Model, occurs when the momentum transfer satisfies $qR \leq 1$, causing the entire nucleus to respond coherently and the cross section to scale approximately with N^2 (the number of neutrons). The CONUS+ experiment, located at the Leibstadt Nuclear Power Plant (Switzerland) and employing high-purity germanium detectors, reports evidence of CEνNS with reactor antineutrinos corresponding to an exposure of 327 kg·day and a statistical significance of 3.7σ. These data make it possible to probe the effective weak mixing angle at very low Q^2, providing a complementary precision test to high-energy measurements, and to constrain new-physics scenarios. The results from CONUS+ restrict possible phenomena such as non-standard neutrino–quark interactions (NSI), the existence of light mediators (scalar and vector), and electromagnetic properties of neutrinos—including their magnetic moment, effective charge radius, and possible millicharge. In addition, short-baseline active–sterile oscillations and sterile-state production are explored. This contribution will present the limits set by CONUS+ on the weak mixing angle and on the aforementioned new-physics scenarios, as reported in the scientific literature.

LHC / **63**

The role of convergence methods as fitting functions in the context of the MUonE experiment

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The MUonE experiment is designed to extract the hadronic contribution to the electromagnetic coupling in the spacelike region $\Delta\alpha_{had}(t)$ from elastic $e\mu$ scattering. The leading-order hadronic vacuum polarization contribution to the muon $g-2$, $a^{HVP;LO}$, can then be obtained from a weighted integral over $\Delta\alpha_{had}(t)$. This, however, requires knowledge of $\Delta\alpha_{had}(t)$ in the whole domain of integration, which cannot be achieved by experiment. In this work, we propose to use Pade and D-Log Pade approximants as a systematic and model-independent method to fit and reliably extrapolate the future MUonE experimental data, extracting $a^{HVP;LO}$ with a conservative but competitive uncertainty, using no or very limited external information. The method relies on fundamental analytic properties of the two-point correlator underlying $a^{HVP;LO}$ and provides lower and upper bounds for the result for $a^{HVP;LO}$. We demonstrate the reliability of the method using toy datasets generated from a model for $\Delta\alpha_{had}(t)$ reflecting the expected statistics of the MUonE experiment.

Posters / **64**

SIMULACIÓN DE LA DETECCIÓN DE MUONES ATMOSFÉRICOS POR INTERACCIÓN CON EL PLÁSTICO CENTELLADOR BC408 IMPLEMENTANDO GEANT4 Y ROOT

Authors: Armando José Moreno Ramos[1]; Erik Owend Maestre Mindiola[1]; Harold Camargo Ávila[1]; Mario A. Acero Ortega[None]

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Con una masa de 106 MeV/c2 y una vida media de 2.2 μs, los muones son las partículas más abundantes a nivel del mar, donde llegan con una energía media de 4 MeV, provenientes del resultado de interacciones de protones y núcleos pesados (rayos cósmicos primarios) con la atmósfera terrestre. Con el objetivo de reproducir de manera realista la interacción de estos muones en un plástico centellador, se propone estudiar algunos modelos para describir su flujo a nivel del mar, introduciendo adecuadamente la distribución angular con la que llegan los muones y la distribución de la energía depositada por estos en el material, mediante el uso de herramientas computacionales de código abierto como GEANT4 y ROOT. Esta simulación se constituirá en una de las bases fundamentales para un estudio experimental en el que se medirá el flujo de muones mediante un detector basado en un plástico centellador BC408 y un fotomultiplicador de silicio.

Posters / **65**

Análisis de la sensibilidad a la violación CP en el decaimiento D+ ⟶ π +π +π-

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En 1964, los físicos Cronin y Fitch descubrieron una violación a la simetría CP en el decaimiento de Kaones neutros, desde entonces se ha encontrado que la violación CP aparece en otros mesones, en 2001 se evidencio violación CP en mesones B, y en 2011 se evidenció el hallazgo en los mesones D. Nuestro estudio tiene como objetivo realizar un análisis a la violación de esta simetría en el decaimiento $D^+ \to \pi^+\pi^+\pi^-$ y su decaimiento conjugado (con las antipartículas correspondientes) en los canales resonantes $\omega(782)$, $\rho(1450)^0$, $\rho(1700)^0$ y $f_2(1270)$. Dicho estudio esta basado en el análisis angular desarrollado en el LHCb en el documento Amplitude analysis of the $D^+ \to \pi^+\pi^+\pi^-$ decay and measurement of the $\pi^+\pi^-$ S-wave amplitude. Este análisis permitirá plantear un punto de partida para analizar la violación CP en los diferentes canales resonantes ya mencionados, todo esto mediante la herramienta computacional Laura++. Una vez las variables de ajuste estén estadísticamente correspondidas entre el modelo computacional y los datos del LHCb, se procederá a construir el análisis de CP dentro del Laura++ lo que permitirá concluir acerca de la eficiencia del modelo y la violación CP en este preciso decaimiento.

Palabras clave: Simetría CP, mesones D, canales resonantes, variables de ajuste

Posters / **66**

Implementación de un detector de muones portátil para la obtención de mediciones de energía e imágenes.

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La muografía, técnica basada en la detección de muones atmosféricos provenientes del espacio exterior, se ha consolidado como una herramienta innovadora para la exploración no invasiva de la morfología de estructuras u objetos. Este desarrollo ha impulsado la búsqueda de materiales, configuraciones y sistemas de detección que permiten medir la intensidad, dirección y la energía de los muones. Tales mediciones posibilitan la generación de imágenes de estructuras u objetos cuya morfología interna es desconocida.

En este trabajo se propone el diseño e implementación de un conjunto de detectores de muones portátiles orientados a medir la energía depositada por estas partículas. El objetivo es desarrollar una metodología de muografía portátil, económica y adaptable a estudios experimentales a pequeña escala, contribuyendo así al avance de las técnicas de detección de radiación cósmica y su aplicación en investigaciones científicas y tecnológicas.

Dark Matter / **67**

First-Order Phase Transitions in the Dark Sector

Author: Andres Gomez[1]

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SIMP dark matter can be realized through low-energy $SU(N_c)$ effective theories, where dark matter consists of the Goldstone bosons associated with the spontaneous breaking of chiral symmetry, the dark pions. The restoration of this symmetry in the early universe may proceed through a first-order phase transition (FOPT), capable of generating a stochastic background of gravitational waves observable by future experiments such as LISA, DECIGO, or BBO.

We show that a θ-term induced by instanton effects in QCD-like vacua, can trigger such a FOPT. The analysis is performed in a QCD-like theory with $N_c = 3$, using the linear sigma model with three coupled quark flavors, focusing on the vacuum structure for $\theta = 0$ and $\theta = \pi$, and the resulting gravitational-wave spectrum.

Dark Matter / **68**

Gravitational Waves from Electroweak Phase Transition in a Z6-Symmetric Dark Matter Model

Authors: Daniel Ruiz Mejía[1]; Oscar Zapata[None]

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We investigate the nature of the electroweak phase transition (EWPT) in a minimal Z_6-symmetric extension of the Standard Model, featuring a fermionic dark matter candidate (ψ_L, ψ_R) and a real scalar singlet (ϕ). Selecting benchmark points that satisfy both the observed dark matter relic density and direct detection constraints, we analyze whether the EWPT is first-order in this scenario. Our study demonstrates how specific parameter choices can enhance the strength of the phase transition, providing a starting point for electroweak baryogenesis. Furthermore, we compute the resulting stochastic gravitational wave background from the first-order phase transitions of our viable benchmarks and assess their detectability in future observatories such as LISA, BBO, and DECIGO.

Posters / **69**

Caracterización experimental de un fotomultiplicador aplicado al análisis de radiación electromagnética láser de baja potencia

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Los fotomultiplicadores son dispositivos de detección altamente sensibles que permiten medir con gran precisión niveles bajos de radiación electromagnética, en particular en el rango óptico. En este proyecto se propone la caracterización experimental de un fotomultiplicador comercial, utilizando como fuente de radiación láseres rojos de bajo costo (625–740 nm).

Se estudiarán parámetros como la ganancia, la linealidad, la respuesta temporal y la sensibilidad espectral del fotomultiplicador mediante un montaje experimental que incluye un osciloscopio digital y un sistema de adquisición de datos.

El objetivo es establecer la respuesta del detector frente a variaciones controladas de intensidad y longitud de onda, evaluando su comportamiento para futuras aplicaciones en mediciones de radiación cósmica, fluorescencia y otras áreas de física experimental.

Además, se integrará un análisis de ondas electromagnéticas, abordando cómo la interacción de la radiación láser con el fotomultiplicador depende de su naturaleza ondulatoria y su energía. Este trabajo aporta al desarrollo de capacidades experimentales en detección óptica y promueve el uso seguro de láseres en entornos académicos.

LHC / **70**

Estudio de la alta multiplicidad de jets de bajo pt en la producción del bosón Z′ y su posible corrección mediante algoritmos de agrupamiento

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[2] *Universidad del Cauca*

Este estudio se centra en el desarrollo y aplicación de un algoritmo de agrupación de jets orientado a mejorar la reconstrucción del proceso
□□→□′→□□⁻ en un modelo simplificado que extiende el Modelo Estándar mediante una simetría gauge adicional □(1)B, asociada al número bariónico calibrado. El objetivo principal es optimizar la identificación experimental del bosón □′ en detectores como el CMS, reduciendo las discrepancias entre las simulaciones y las predicciones teóricas.

Las simulaciones del proceso se realizaron con MadGraph5_aMC@NLO para la generación de eventos, Pythia8 para la hadronización y Delphes para la emulación del detector. En los análisis realizados se observó un exceso significativo en el número de jets reconstruidos por evento, dificultando la identificación del par de jets originado en el decaimiento del □′.

Para abordar este problema, se implementó un algoritmo de reagrupamiento basado en la distancia angular Δ□, que suma jets próximos en el espacio de fase, imitando de forma más realista la estructura de los chorros producidos en el decaimiento hadrónico del bosón. La aplicación del algoritmo redujo la multiplicidad de jets por evento, obteniéndose predominantemente configuraciones de dos jets, en concordancia con las predicciones teóricas del canal □□⁻.

Dark Matter / **71**

Dark sector with fermion dark matter and a dark scalar.

Authors: Amalia Betancur Rodriguez[1]; Gustavo Adolfo Castrillon Yepes[2]; Oscar Zapata[None]

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In this talk, we introduce a fermionic dark-matter model whose interactions with the Standard Model proceed via vector and scalar mediators. We will show that the model exhibits a rich dark matter phenomenology, while also possessing a constrained parameter space that can be further probed by future experiments.

Theory and BSM / **72**

Corrección a la masa del pion neutro mediante el modelo sigma en un campo magnético.

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En este trabajo se analiza la variación de la masa del pión neutro en función de un campo magnético externo, utilizando el Modelo Estándar dentro de la aproximación del límite del gran N. Para ello se recurre al método de Schwinger en el cálculo del propagador de Feynman, en lugar de los métodos algebraico o de integral de trayectoria, debido a que el propagador relativista parece presentar una

dimensión adicional y este enfoque ofrece una solución adecuada a dicho problema. A partir del lagrangiano se derivaron las reglas de Feynman, las cuales permitieron calcular las correcciones radiativas en presencia del campo magnético. Finalmente, se verificó el comportamiento de la masa del pión neutro en función de la intensidad del campo y se compararon los resultados con los obtenidos mediante los modelos LQCD, NJL y LSMq.

Posters / **73**

Simulación de detección de neutrinos mediante Geant4

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Geant4 es una herramienta de software que permite la simulación del paso de la partículas mediante materiales organizados en una geometría compleja, en el cual las interacciones débiles se limitan a la desintegración de partículas y la captura de electrones por los núcleos [1]. Los neutrinos son partículas fermionicas con una sección de interacción muy baja, que se producen en la desintegración de partículas inestables [2], o en la captura de electrones [1].
El poder simular las interacciones débiles en Geant4 es de suma importancia ya que permite simularlas y rastrear los neutrinos desde el punto de producción hasta el punto de interacción, ya que construye el punto de interacción inicial en la geometría, posteriormente el generador de eventos como GENIE,NEUT o GiBUU, que permiten simular las interacciones de neutrinos, sin embargo la interfaz en Geant4 no es directa [1],
para simular una interacción de neutrinos Geant4 debe de calcular la sección eficaz del neutrino.
El describir los procesos físicos permite realizar simulaciones en los procesos de flujo en detectores cercanos y lejanos [3], construyendo la interacción débil del neutrino durante el trayecto, trazando su recorrido
hasta el detector. La detección de la energía y trayectoria se realiza de forma indirecta [2] mediante la colisión del neutrino con un electrón, dejando una huella observable que es detectada por los fotomultiplicadores, con lo cual se reconstruye la dirección y energía del neutrino [1].
Se busca el poder simular las interacciones de los neutrinos, requiriendo un generador de eventos, el cual debe de ser usado desde otro software, que permita la construcción de la trayectoria, la cual aun no ha sido construida en el software Geant4, buscando su plausibilidad, y aplicabilidad.
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Posters / **74**

Limites en las masas de los neutrinos en el decaimiento doble beta sin neutrinos

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Se estudia el espacio paramétrico de neutrinos, obteniendo algunos limites en las masas de los neutrinos en el decaimiento doble beta sin neutrinos, en escenarios de cero, uno y dos neutrinos estériles, mediante los últimos datos experimentales de neutrinos y una conjunción entre las restricciones de decaimiento doble beta sin neutrinos, decaimiento beta del Tritio (KATRIN) y las observaciones cosmológicas de rayos X.

Theory and BSM / **75**

Higgs-like Resonances in a 3-3-1 Model

Author: Alex Tapia[1]

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Recent experimental results have reported mild deviations from Standard Model predictions in processes involving two photons in the final state, suggesting the possible presence of high-mass scalar resonances at the few-hundred-GeV scale. We investigate these anomalies within the framework of 3-3-1 models, a well-motivated class of extensions of the Standard Model. Focusing on the most relevant regions of parameter space, we determine the preferred scalar mass ranges and present the results in terms of probability density functions. We implement the 3-3-1 model with right-handed neutrinos, which can be considered as a benchmark within this class of models, in the SARAH package. The scalar sector is constructed from the most general potential involving three Higgs triplets and one scalar sextet, consistent with the required symmetries for a realistic model.

Posters / **76**

Cancellation of Quadratic Divergences in an $\mathcal{N} = 1$ Supersymmetric Yang–Mills Theory

Authors: Eduardo Rojas[1]; Farid Riascos Meneses[2]

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This undergraduate thesis systematically develops the construction of the supersymmetric Lagrangian for gauge theories with $\mathcal{N} = 1$ supersymmetry. Starting from the physical and algebraic foundations of quantum field theory and spacetime symmetries, it introduces the formalism of superspace and superfields as tools to formulate supersymmetric theories. As an application, the cancellation of quadratic divergences in radiative corrections to the Higgs mass is analyzed, highlighting the role of supersymmetry in naturally stabilizing the electroweak scale. The approach taken aims not only to present the final results but also to rigorously show the explicit derivation of each term, thereby providing conceptual clarity to the supersymmetric formalism.

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Simulation and Performance Study of a Scintillator Cube Detector for Electron Tracking Using GEANT4

Author: Julian Diaz[1]

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This work presents the simulation and study of a three-dimensional scintillator bar detector for the analysis of 100 MeV electrons, using the GEANT4 toolkit. The detector design consists of a segmented array of scintillator cubes, each coupled to a wavelength-shifting (WLS) optical fiber and a silicon photomultiplier (SiPM). This computational study is complemented by an ongoing proof-of-concept involving the physical construction of a two-bar prototype. The simulation models the interaction of high-energy electrons with the scintillator material, the generation and transport of optical photons, and their detection by SiPMs. The detector's performance is characterized in terms of trajectory reconstruction efficiency, spatial resolution, and the correlation between deposited energy and detected optical signal. Results indicate a reconstruction efficiency between 40% and 70% for most events, while spatial resolution is primarily limited by the physical size of the scintillator cubes. A clear positive correlation between deposited energy and the number of detected photons is observed for energies above 50-100 MeV, validating the correct implementation of the optical processes. This study demonstrates the feasibility of the proposed 3D detector concept and provides a foundation for optimizing future designs for high-energy particle tracking.

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Determining charge for heavy flavour tagged jets in CMS with a Graph-Based Particle Transformer

Authors: Clara Ramon Alvarez[1]; Cristina Ana Mantilla Suarez[1]; Edgar Fernando Carrera Jarrin[2]; Jose David Ochoa Flores[2]

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We present a novel technique to determine the charge of b-tagged small-cone jets in the CMS experiment. While current heavy-flavour tagging algorithms are charge-agnostic, the ability to distinguish between b and anti-b (as well as c and anti-c) jets is essential for several physics analyses, including Higgs and di-Higgs production studies. The proposed method leverages the Particle Transformer architecture, trained on simulated samples using a graph-based representation that connects all Particle Flow candidates and Secondary Vertices within a jet. The resulting charge-sensitive tagger, now fully integrated within the CMSSW framework, outperforms traditional jet-charge proxy variables, providing a robust and scalable tool for exploiting charge information in heavy-flavour jets. Ongoing studies using H and HH samples demonstrate the physics potential of this approach for improving charge-dependent measurements and enhancing signal–background discrimination in future CMS analyses.

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Towards Low-pT Quantum b-Tagging with Variational Circuits

Authors: Jose Ruiz[1]; Juan Montoya[2]; Sebastian Duque Mesa[None]; Tomas Sosa Giraldo[3]

[1] *Universidad de Antioquia (CO)*

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We explore quantum machine learning (QML) for b-tagging at pT < 20 GeV, where taggeing b-jets from light/c-jets is challenging. We propose classifiers based on variational quantum circuits (VQCs) implemented in PennyLane, compared against classical ML techniques with equivalent parameter counts. The pipeline shares preprocessing with classical methods for fair comparison. We evaluate generalization, sample complexity, AUC. This study aims to identify conditions where QML offers advantages for challenging HEP tasks in the low-pT regime.

Dark Matter / **80**

Pion dark matter in a θ vacuum: a thermal relic with sharp velocity-dependent self-interactions

Author: Oscar Zapata[None]

As recently proposed, a non-vanishing topological angle may play a central role in QCD-like theories of dark matter (DM). In this work, we introduce a dark photon portal to the Standard Model in order to establish thermal equilibrium in the early Universe, and discuss the ensuing phenomenological constraints, including the stability of DM. The resulting dynamics accounts for the observed DM relic abundance and yields velocity-dependent DM self-interactions in astrophysical halos. Due to the sharp velocity dependence arising from a Breit-Wigner resonance, dedicated studies are required to assess the gravothermal evolution in detail, especially in the core-collapse regime. This is particularly timely in light of self-interacting DM interpretations of strong-lensing systems such as SDSS J0946+1006, which can be naturally explained within our framework.

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Experimental development of a Cherenkov detector applying colloidal suspension to improved atmospheric muon detection.

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This project presents the design and experimental development of a Cherenkov detector for atmospheric muons that incorporates solid-phase colloids to enhance detection efficiency. The detector medium consists of a TiO_2 nanoparticle suspension (average particle size ≈ 298 nm) dispersed in a glycerin–deionized water mixture at concentrations above 0.5 %, achieving a refractive index greater than 1.38. This modification is intended to increase Cherenkov photon production within the detection volume. The detector is composed of a 35 L polyethylene tank instrumented with four 6 mm silicon photomultipliers (SiPMs) operating in independent channels. The project is currently in progress, focusing on optimizing the optical properties of the colloidal medium and evaluating its potential to improve photon yield and detection efficiency compared to conventional water-based configurations.

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Hybrid Equations of State for Neutron Stars in the Togashi–Prakash–NJL Framework

Author: Felipe Ricardo Amador Velasquez[1]

[1] *Universidad Nacional de Colombia*

In this work, we analyze the internal structure of neutron stars using hybrid equations of state that combine hadronic and quark degrees of free-dom within a unified framework. The stellar crust is described through the Togashi model, which ensures thermodynamic consistency across the nuclear saturation regime, while the nucleonic region follows the Prakash formulation for 3-stable matter. The deconfined quark phase is modeled with the three-flavor Nambu-Jona-Lasinio (NJL) approach, considering. variations in the vector and diquark couplings (gv/G, H/G) to system-atically study their influence on macroscopic properties. By numerically solving the Tolman-Oppenheimer-Volkoff equations for each parameter set, we obtain the mass-radius relations, crust thickness, and quark core radius. The results identify stable hybrid configurations consistent with current observational constraints on neutron star masses and radii, contributing to the understanding of phase transitions in dense QCD matter and the emergence of quark cores in compact stars.

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Quantum corrections to self-energies in the linear sigma model with spin density at finite temperature

Author: Larry Andrik Ceron Suarez[1]

Co-author: Jorge David Castaño Yepes [1]

[1] *Universidad del Valle*

El estudio de la materia fuertemente interactuante bajo condiciones extremas de temperatura, densidad de espín y vorticidad es fundamental para comprender la dinámica del plasma de quarks y gluones producido en colisiones no-centrales de iones pesados relativistas. En este contexto, se propone un trabajo en curso que extiende el modelo sigma lineal acoplado a quarks mediante la inclusión explícita de la densidad de espín en el lagrangiano efectivo, con el fin de explorar cómo la rotación y la polarización modifican las propiedades de los campos cuánticos y las masas efectivas de bosones y fermiones.

La investigación contempla una expansión a primer orden en los acoplamientos de los campos cuánticos para obtener las contribuciones dominantes al potencial efectivo, así como la identificación de los diagramas de Feynman relevantes que determinan las autoenergías bosónicas y fermiónicas a un loop. Además, se plantea una revisión crítica de la literatura reciente que aborda efectos vorticales en el modelo sigma lineal, con el propósito de incorporar correcciones teóricas y extender los resultados existentes más allá de la aproximación de campo medio. Este estudio busca aportar una descripción más completa de la ruptura y restauración de la simetría quiral en presencia de vorticidad, con implicaciones directas para la fenomenología observada en colisiones de iones pesados en el LHC y el RHIC.

Abstract
The study of strongly interacting matter under extreme conditions of temperature, spin density, and vorticity is essential to understanding the dynamics of the quark–gluon plasma produced in non-central relativistic heavy-ion collisions. In this context, we present an ongoing research proposal that extends the linear sigma model coupled to quarks by explicitly incorporating spin density into the effective Lagrangian. The aim is to explore how rotation and polarization modify the behavior of quantum fields and the effective masses of bosons and fermions.

The investigation involves a first-order expansion in the couplings of the quantum fields to obtain the leading contributions to the effective potential, as well as the identification of the relevant one-loop Feynman diagrams that determine the bosonic and fermionic self-energies. Furthermore, we plan to include a critical review of recent literature addressing vortical effects in the linear sigma model, in order to introduce theoretical corrections and extend previous results beyond the mean-field approximation. This study seeks to provide a more complete description of chiral symmetry

breaking and restoration in the presence of vorticity, with direct implications for the phenomenology observed in heavy-ion collisions at the LHC and RHIC.

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Production of scalar bosons through vector boson fusion in a rotating medium

Authors: Guillermo Javier Madroñero Pabon[1]; Jorge David Castaño Yepes[1]; Leidy Natalia Jiménez Muñoz[1]

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In non-central collisions, the anisotropic distribution of matter generates orbital angular momentum that induces significant vorticity in the medium, making the dynamics of particles within the QGP dependent not only on temperature and external fields but also on rotational effects. Such phenomena motivate the use of effective descriptions incorporating metrics analogous to curved spacetime, formulated in cylindrical coordinates to represent the system's global rotation. Within this framework, scalar fields such as the Higgs boson become particularly relevant through their interactions with massless vector bosons—gluons or photons—processes that in vacuum lead to boson production via gluon fusion but may be significantly modified in thermal and rotating media. The present work reproduces the calculation of the fermionic propagator in a rotating medium and the probability amplitude for scalar boson production via vector boson fusion in vacuum, establishing the groundwork for a more comprehensive analysis that explicitly includes rotational effects. Building upon this, the evaluation of the fermionic triangle diagram using the obtained propagator is proposed to estimate the likelihood of scalar boson formation in a vortical plasma, thereby contributing to the characterization of scalar–vector couplings in rotating quark–gluon systems and to a deeper understanding of high-energy collision phenomenology.

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OPTIMIZATION OF THE SCHRÖDINGER-POISSON MODEL USING B-SPLINES

Author: Jeison Stiven Lenis Trujillo[1]

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Large-scale structures in the universe can be studied through N bodies interacting gravitationally. In this work, we approximate this process using a quantum dust fluid in one spatial dimension, described by the **Schrödinger-Poisson equations**. The temporal evolution of the system is calculated using B-splines within the Crank-Nicolson propagator implemented in a predictor-corrector scheme. We analyze different cosmological models and obtain the power spectrum of matter. For future improvements, we aim to reduce the calculation time and incorporate parameters that more accurately reproduce observational results.

Theory and BSM / 86

Domain wall collapse is catastrophic.

Author: Juan Sebastian Valbuena-Bermudez[None]

The evolution of domain wall networks is essential to understanding our cosmological history. We will consider the scenery after which the degeneracy of the vacuum is broken, and bubbles of the false vacuum will start to collapse. I will discuss the interesting dynamics in these processes, caustics formation, and the fascinating connection to Catastrophe theory and geometric optics through the eikonal equation. Finally, we will discuss the possible implications for primordial black hole formation and gravitational wave radiation.

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Estudio de CEvNS enfocado a la producción de fermiones estériles por up-scattering

Authors: Blanca Orduz[1]; Esneider Guerrero[1]

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En este trabajo se abordará un estudio fenomenológico de la dispersión elástica coherente neutrino-núcleo (CEvNS) enfocado a la producción de un fermión estéril a través del proceso de up-scattering neutrino-núcleo mediado por un bosón escalar neutro. Se presentará un análisis estadístico preliminar enfocado a determinar posibles restricciones a la masa del fermión estéril y a la constante de acoplamiento con el nuevo bosón escalar neutro considerando los resultados experimentales de CONUS+.

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Simplified dark matter model with novel Vector Boson Fusion signatures for searches at colliders

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We investigate the potential to search for dark matter within a simplified model that introduces a new scalar/vector resonance connecting the Standard Model (SM) to the dark sector composed by a Dirac fermionic dark matter particle. This mediator couples to SM vector bosons, including gluons, giving rise to novel Vector Boson Fusion (VBF) topologies. These allow for the exploration of such signatures at collider experiments. We analyze the constraints on the model's Wilson coefficients and other parameters from direct and indirect detection experiments, as well as from measurements of the dark matter relic abundance.

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Caracterización de fibras ópticas de un detector de partículas usando IA (Estado actual)

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En el contexto del sistema de calibración del sensor de fotones del detector lejano del proyecto DUNE se requiere realizar la implementación de una tecnología innovadora llamada Power over Fiber la cual, a grandes rasgos, consiste en transmitir energía proporcionada por un láser de alta potencia a través de fibra óptica.
Para cumplir con este objetivo es necesario contar con fibras ópticas de muy alta calidad con el fin de optimizar el funcionamiento del proceso.
Se pretende en este proyecto proporcionar elementos de juicio para decidir si una fibra óptica es elegible, o no, para ser utilizada en la línea de transmisión. Todo esto con base en la imagen de un corte transversal de dicha fibra y con la ayuda de una red neuronal, superando el déficit de muestras de entrenamiento con un riguroso preprocesamiento de las imágenes disponibles.
Avances sobre el preprocesamiento de las imágenes y diseño de la arquitectura de la red neuronal y corrección en el algoritmo de generación de muestras artificiales.

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