MOCa 2019: Materia Oscura en Colombia

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Dark Sector Physics with Belle II

Autor: Ida Peruzzi[1]

[1] *Laboratori Nazionali di Frascati dell'INFN*

Corresponding Author: peruzzi@slac.stanford.edu

The Belle II experiment at the SuperKEKB energy-asymmetric e^+e^- collider is a substantial upgrade of the B factory facility at the Japanese KEK laboratory. The design luminosity of the machine is 8×10^{35} cm^{-2}s^{-1} and the Belle II experiment aims to record 50 ab^{-1} of data, a factor of 50 more than its predecessor. From February to July 2018, the machine has completed a commissioning run, achieved a peak luminosity of 5.5×10^{33} cm^{-2}s^{-1}, and Belle II has recorded a data sample of about 0.5 fb^{-1}. Main operation of SuperKEKB has started in March 2019 and about 10 fb $^{-1}$ integrated luminosity is expected by the end of June. This early data set, with specifically designed triggers, already offers the possibility to search for a large variety of dark sector particles in the GeV mass range complementary to LHC and dedicated low energy experiments; these searches will benefit from more data in the process of being accumulated. This talk will review the state of the dark sector searches at Belle II with a focus on the discovery potential of the early data, and show the first results

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Non-universal electroweak extensions of the standard model and the scotogenic models.

Autor: Eduardo Rojas[1]

[1] *Universidad de Nariño*

Corresponding Author: eduro4000@gmail.com

In order to analyze some low energy experimental anomalies, we charge with a non-universal U(1)0 gauge symmetry the standard model fermions, taking as a starting point the well-known scotogenic model. In order to have non-trivial solutions to the anomalies and the Yukawa constraints, we add three neutral singlet Dirac fermions. We have found two possible nonuniversal solutions which, as a matter of principle, are suitable to analyze family-dependent experimental anomalies.

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Singlet-Doublet Dirac Dark Matter and Neutrino Masses

Autor: Andrés Felipe Rivera Romero[1]

Co-autores: Diego Restrepo [1]; Walter Tangarife [2]

[1] *Universidad de Antioquia*

[2] *Loyola University Chicago*

Corresponding Authors: wtangarife@luc.edu, afelipe.rivera@udea.edu.co, restrepo@udea.edu.co

We examine an extension of the Standard Model that addresses the dark matter puzzle and generates Dirac neutrinos masses through the radiative seesaw mechanism.
The new field content includes a scalar field that plays an important role in setting the relic abundance of dark matter.

We analyze the phenomenology in the light of direct, indirect, and collider searches of dark matter. In this framework, the dark matter candidate is a Dirac particle that is a mixture of new singlet-doublet fields with mass 1.1 TeV.
We find that the allowed parameter space of this model is broader than the well-known Majorana dark matter scenario.

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Reconstructing Non-standard Cosmologies with Dark Matter

Autor: Nicolás Bernal[1]

[1] *Universidad Antonio Nariño*

Corresponding Author: nicolas.bernal@uan.edu.co

Once dark matter has been discovered and its particle physics properties have been determined, a crucial question rises concerning how it was produced in the early Universe. If its thermally averaged annihilation cross section is in the ballpark of few×10^{-26} cm3/s, the WIMP mechanism in the standard cosmological scenario (i.e. radiation dominated Universe) will be highly favored. If this is not the case one can either consider an alternative production mechanism, or a non-standard cosmology. Here we study the dark matter production in scenarios with a non-standard expansion history. Additionally, we reconstruct the possible non-standard cosmologies that could make the WIMP mechanism viable.

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Phenomenological and experimental searches for compressed stau-neutralino production at the LHC

Autores: Alfredo Gurrola[1]; Andrés Floréz [2]; Savanna Starko [3]; Alejandro Segura[4]

[1] *Vardelbilt University*

[2] *Universisty los Andes*

[3] *Vanderbilt University*

[4] *University Los Andes*

We present an experimental search of Supersymmetry motivated by electrowikinos production in the electro-weak sector using the CMS experiment at $\sqrt{s} = 13$ TeV. Data comes from proton-proton (pp) collisions corresponding to 35.9 and 41.3 fb^{-1} collected during 2016 and 2017 respectively. We focus in final states containing a hadronic tau (τ_h) of low transverse momentum (p_T), an initial state radiation jet (ISR), and a large imbalance of missing transverse energy (p_T^{miss}). By selecting an ISR jet in the final states, the SUSY signal in a kinematic region called compress mass spectra scenarios is maximized, where the mass difference between the stau ($\tilde{\tau}$) and the lightest supersymmetric particle, the neutralino ($\tilde{\chi}_1^0$) is small. This search has a special scientific interest due to the direct connection between particle physics and cosmology, in which, to obtain the correct relic dark matter density measured by the cosmology ($\Omega_{DM}h^2 = 0.1186 \pm 0.002$) in thermal dark matter models, the mass between the $\tilde{\tau}$ and the $\tilde{\chi}_1^0$ must be small. The phase space for the compressed stau has been difficult to prove at the LHC, nevertheless, no data excess is observed over the standard model estimation. The exclusion limits at 95% of confidence level were established for the democratic scenario where $m(\tilde{\tau}) = 0.5m(\tilde{\chi}_1^{\pm}) + 0.5m(\tilde{\chi}_1^0)$. For the total cumulative luminosity of 2016 and 2017 (77.2 fb^{-1}), chargino masses are excluded up to $m(\tilde{\chi}_1^{\pm}) < 290$ GeV, where the mass gap between the chargino and the neutralino is $m(\tilde{\chi}_1^{\pm}) - m(\tilde{\chi}_1^0) = 50$ GeV.

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On the Optical Properties of Cosmic Telescopes: A Spectroscopy study of the inner core of a Massive Galaxy Cluster

Autores: Camilo Delgado-Correal[1]; Piero Rosati[2]; CLASH-VLT Team[None]

[1] *GCPA & Università degli Studi di Ferrara*

[2] *Università degli Studi di Ferrara*

Corresponding Author: m.camilo.d@gmail.com

We have used a VLT-VIMOS data-set and analyzed VLT-MUSE data on the inner core of a galaxy cluster, obtaining spectra and measuring with high precision redshifts of cluster members, which were used to make an ATLAS of the galaxy population diversity that will be useful in further studies. We also used this spectroscopic information to classify the galaxy population as a function of the radio cluster center distance of a massive galaxy cluster to verify if it was in agreement with the observed distribution in others clusters at the same redshift. Finally, We described the projected number density profile and the stellar mass function of a massive galaxy cluster at intermediate redshift.

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Einstein Yang-Mills Higgs dark energy revisited

Autores: J. Bayron Orjuela-Quintana[1]; Miguel Álvarez[2]; Yeinzon Rodríguez[2]; César Valenzuela-Toledo[3]

[1] *Universidad Del Valle*

[2] *Universidad Industrial de Santander*

[3] *Universidad Del Valle*

Corresponding Author: john.orjuela@correounivalle.edu.co

Inspired in the Standard Model of Elementary Particles, the Einstein Yang-Mills Higgs action with the Higgs field in the SU(2) representation was proposed in Class. Quantum Grav. 32 (2015) 045002 as the element responsible for the dark energy phenomenon. We revisit this action emphasizing in a very important aspect not sufficiently explored in the original work and that substantially changes its conclusions. This aspect is the role that the Yang-Mills Higgs interaction plays at fixing the gauge for the Higgs field, in order to sustain a homogeneous and isotropic background, and at driving the late accelerated expansion of the Universe by moving the Higgs field away of the minimum of its potential and holding it towards an asymptotic finite value. We analyse the dynamical behaviour of this system and supplement this analysis with a numerical solution whose initial conditions are in agreement with the current observed values for the density parameters. This scenario represents a step towards a successful merging of cosmology and well-tested particle physics phenomenology.

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Multicomponent dark matter and the inert doublet model

Autor: Amalia Betancur Rodríguez[1]

[1] *Universidad EIA*

Corresponding Author: amalia.betancur@eia.edu.co

Multicomponent dark matter models are an interesting solution to the challenges that simplified models face under current experimental constraints. The relic abundance is saturated due to the interplay of two or more dark matter candidates that may or may not affect each others relic density. One interesting possibility arises when the two dark matter candidates are part of the inert doublet models and mixed fermionic $SU(2)_L$ multiplets. In this talk, I will focus on such possibilities and I will show that it is possible to recover the region where the mass of the scalar DM candidate lies below 550 GeV. Moreover, I will show that despite the larger parameter space and the greater difficulties faced by multicomponent dark sectors, it is possible to impose constraints coming from current dark matter searches.

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Simulando materia oscura colisional

Autor: Javier Alejandro Acevedo Barroso[1]

Co-autor: Jaime Forero-Romero [1]

[1] *Universidad de los Andes*

Corresponding Authors: j.e.forero.romero@gmail.com, ja.acevedob12@gmail.com

La búsqueda de la materia oscura es una empresa conjunta entre la física de partículas y la astrofísica. A partir de evidencia astrofísica sabemos que la partícula de materia oscura debe estar por fuera del modelo estándar.
No obstante, tal partícula debe tener propiedades de partícula bien definidas, incluyendo su sección eficaz. Esto significa que la materia oscura debe ser en algún grado colisional. Sin embargo, la materia oscura se ha simulado como un fluido no colisional. Esta aproximación ha tenido gran éxito explicando las propiedades del universo a gran escala. En esta charla presentaré un algoritmo que permite simular materia oscura colisional. El método resuelve la ecuación de Boltzmann usando la aproximación Bhatnagar-Gross-Krook (BGK) en un Lattice entero, esto permite simular el espacio de fase de un fluido colisional de materia oscura y ajustar su grado de colisionalidad usando como parámetro libre el tiempo de relajación carácteristico τ. Presentaré pruebas numéricas en un espacio de fase 2D utilizando versiones simplificadas de la inestabilidad de Jeans y atenuación de Landau. Al final mencionaré posibles aplicaciones sobre modelos del Bullet Cluster simplificados.

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Materia Oscura: retos y problemas abiertos

Autor: Carlos E. Yaguna[None]

Corresponding Author: cyaguna@gmail.com

Presentaré algunos de los problemas abiertos mas importantes en el area de fenomenologia de la materia oscura y unas cuantas ideas recientes sobre como afrontarlos.

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Dark matter halo shapes in the Auriga simulations

Autores: Jesus Prada[1]; Jaime Forero-Romero[1]; Robert Grand[2]; Ruediger Pakmor[2]; Volker Springel[2]

[1] *Uniandes*

[2] *Max Planck for Astrophysics*

We present shape measurements of Milky Way-sized dark matter halos at redshift $z = 0$ in a suite of 30 zoom simulations from the Auriga project. We compare the results in full magnetohydrodynamics against dark matter only simulations and find a strong influence of baryons in making dark matter haloes rounder at all radii compared to their dark matter only counterparts. At distances ~ 30 kpc, rounder dark matter distributions correlate with extended massive stellar discs and low core gas densities. We measure the alignment between the halo and the disc shapes at different radii and find a high degree of alignment at all radii for most of the galaxies. In some cases the alignment significantly changes as a function of radius implying that the halo shape twists; this effect correlates with recently formed bulges and is almost absent in the dark matter only simulations. In a comparison against observational constraints we find that 20% of halos in our sample are consistent with observational results derived from the Pal 5 stream that favours an almost spherical shape. Including baryons is a required element to achieve this level of agreement. In contrast, none of the simulations (neither dark matter only nor with baryons) match the constraints derived from the Sagittarius stream that favour an oblate dark matter halo.

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Top Quark Interactions in Simplified Dark Matter Models

Autor: Alexander Moreno Briceño[1]

[1] *Universidad Antonio Nariño*

Corresponding Author: alexander.moreno@uan.edu.co

Constraints on the interactions between the Dark Matter (DM) sector and the Standard Model (SM) sector can be established at the LHC. We study possible top quark spin correlation effects on the interactions between DM and top quarks mediated by the exchange of spin-0 and spin-1 particles. We discuss in detail the results of angular correlations and distributions of the top quark which may allows us to explore DM interactions at the LHC.

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Axion inflation with derivative a coupling to the gravitational field

Autor: Juan Pablo Beltran[1]

[1] *Universidad Antonio Nariño*

Corresponding Author: juanpbeltran@uan.edu.co

We discuss a version of the Natural Inflation model in which the inflaton field is an axion (pseudoscalar) field coupled to a U(1) gauge fields through an axial coupling $\phi\tilde{F}F$ and to the gravitational field through the kinetic coupling term $G_{\mu\nu}\partial_\mu\phi\partial_\nu\phi$. The couplings mentioned before are compatible with the shift symmetry $\phi \to \phi + c$ which is a virtue of the model because this makes the theory stable under radiative corrections. The axion acquires a natural cosine like potential term when shift symmetry is spontaneously broken at the natural inflation scale f.

The presence of axial couplings leads to a production of gauge particles which acts as a friction term in the dynamics of the inflaton field, producing a slow-roll regime even in presence of a steep potential and that this interaction provides an efficient mechanism for the sourcing of chiral gravitational

waves. On the other hand, the presence of a kinetic gravitational coupling provides an extra enhancement of the gravitational friction which allows the natural inflation scale to be $f \ll M_p$.

In this talk we discuss some consequences of the introduction of the non-minimal coupling to gravity in this system. During the talk we review some details about the non-minimally coupled dynamics, and discuss the constraints on the model coming from the measurements of cosmological parameters. We put emphasis on the issue of sourced tensor modes in this model. Finally, we comment on further variations and generalizations of this model.

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Mirror world dark matter

Autor: Chee Sheng Fong[1]

[1] *Universidade Federal do ABC*

Corresponding Author: sheng.fong@ufabc.edu.br

The coincidence between baryon and dark energy densities can be quite naturally accommodated if there exists an inexact copy of the Standard Model, the mirror world. We will discuss some of these realizations.

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Charged current b → cτν⁻τ anomalies in a general W' boson scenario

Autor: Eduardo Rojas[None]

Corresponding Author: eduro4000@gmail.com

The very recent experimental information obtained from Belle experiment, along with the one accumulated by the BABAR and LHCb experiments have shown the existence of anomalies in the ratios R(D) and R(D ∗) associated with the charged current transition b → cτν⁻τ . Although the Belle measurements are in agreement with the SM predictions, the new experimental world averages still exhibit tension. In addition, the D ∗ longitudinal polarization FL(D ∗) related to the channel B → D ∗ τν⁻τ observed by the Belle and the ratio R(J/ψ) measured by the LHCb also show discrepancies with their corresponding SM estimations. In this work, we present a model-independent study based on the most general effective Lagrangian that yields to a tree-level effective contribution to the transition b → cτν⁻τ induced by a general W0 gauge boson. Instead of considering any specific new physics (NP) realization, we performed an analysis by considering all the different chiral charges to the charm-bottom and τ -ντ interaction terms with a charged W0 boson that explain the anomalies. We present a phenomenological study of parameter space allowed by the new experimental b → cτν⁻τ data and with the mono-tau signature pp → τhX + MET at the LHC. For comparison, we include some of the W0 boson NP realizations that have already been studied in the literature

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Dark Matter in Non Standard Cosmologies

Autor: James Unwin[1]

[1] *UIC*

Corresponding Author: james.a.unwin@gmail.com

There is a great deal of freedom to propose changes from the standard cosmology history of the universe prior to Big Bang Nucleosynthesis. In this talk I will highlight that such non standard cosmologies can significantly impact the expected relic abundance of dark matter. I will review the classic applications of these ideas to reviving neutralino WIMP dark matter, discuss recent work applying these ideas to different dark matter candidates, and highlight new ideas related to cosmologies with highly non-standard equations of state.

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Round table

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Anapole Dark Matter via Vector Boson Fusion Processes at the LHC

Autores: Andrés Floréz [1]; Carlos Andres Florez Bustos[2]

[1] *Universisty los Andes*

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

Corresponding Author: andres.florez@cern.ch

Dark matter that is electrically neutral but couples to the electromagnetic current through higherdimensional
operators constitutes an interesting class of models. We investigate this class of models
at the Large Hadron Collider, focusing on the anapole moment operator in an effective field theory (EFT) framework, and utilizing the vector boson fusion (VBF) topology. Assuming proton-proton collisions at $sqrt(s) = 13$TeV, we present the VBF anapole dark matter (ADM) cross sections and kinematic distributions as functions of the free parameters of the EFT, the cutoff scale and the ADM mass m. We find that the distinctive VBF topology of two forward jets and large dijet pseudorapidity gap is effective at reducing SM backgrounds, leading to a 5 σ discovery reach for all kinematically allowed ADM masses with $\Lambda <\leq 1.62$ (1.1) TeV, assuming an integrated luminosity of
3000 (100) $fb^{-}1$.

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Searching for DM and HNL with the ATLAS detector

Autor: Gabriela Alejandra Navarro[1]

[1] *Universidad Antonio Narino (CO)*

Corresponding Author: gabriela.navarro@uan.edu.co

Searching for DM and HNL with the ATLAS detector

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Search for Electroweakinos produced via Vector Boson Fusion with the CMS detector in proton-proton collisions at sqrt(s) = 13 TeV

Autor: Carlos Avila Bernal[1]

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

Corresponding Author: carlos.avila@cern.ch

A search for supersymmetric particles produced in the vector boson fusion topology in proton-proton collisions is presented. The search targets final states with one or zero leptons, large missing transverse momentum, and two jets with a large separation in rapidity. The data sample corresponds to an integrated luminosity of 35.9 fb^{-1} of proton-proton collisions at $\sqrt{s} = 13$ TeV collected in 2016 with the CMS detector at the LHC. The observed dijet invariant mass and lepton-neutrino transverse mass spectra are found to be consistent with the standard model predictions. Upper limits are set on the cross sections for chargino ($\tilde{\chi}_1^{\pm}$) and neutralino ($\tilde{\chi}_2^0$) production with two associated jets. For a compressed mass spectrum scenario in which the $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_2^0$ decays proceed via a light slepton and the mass difference between the lightest neutralino $\tilde{\chi}_1^0$ and the mass-degenerate particles $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_2^0$ is 1 (30) GeV, the most stringent lower limit to date of 112 (215) GeV is set on the mass of these latter two particles.