MOCa 2023: Materia Oscura en Colombia

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Book of Abstracts

Contents

1

Alternative 3-3-1 models for \beta = Sqrt{3}

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We report the most general classification of 331 models with $\beta = \sqrt{3}$. We found several solutions where anomaly cancellation occurs between fermions of different families. These solutions are particularly interesting as they generate non-universal (NU) heavy neutral vector bosons. Non-universality in the SM fermion charges under an additional $U(1)$ gauge group generates Charged Lepton Flavor Violation (CLFV) and Flavor Changing Neutral Currents˜(FCNC). Therefore, these models are suitable for studying flavor physics. In Addition, we also report LHC constraints.

2

Multicomponent dark matter with an Extra Abelian Gauge Symmetry

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We propose a model with a multicomponent and multiflavor dark matter which allows the realization of an effective operator for Dirac neutrino masses. Furthermore, it has an extra Abelian gauge symmetry that is spontaneously broken and generates masses for particles in the dark sector and it is responsible for the stability of dark matter candidates. We explore the parameter space of the model and we analyze the impact of the constraint of the relic abundance of the candidates of dark matter.

3

Recent developments on multicomponent dark matter scenarios

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I will present some recent work on the phenomenology of multicomponent dark matter models based on a ZN symmetry.

4

Z6 –symmetric two-component scalar dark matter

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Multi-component scalar dark matter (DM) models based on a single Z_N (N 4) symmetry are simple and well-motivated. In this work, the phenomenology of a Z_6 model with two DM candidates is considered. The scalar sector of the Standard Model (SM) is extended with a second doublet and one complex singlet, both charged under the Z_6 symmetry. The ordinary SM fields remain neutral. The interactions allowed by the Z_6 give rise to processes between the DM particles that affect their relic densities and their detection prospects. By means of a random scan, the viable parameter space of the model is determined. Our results show that DM masses below the TeV scale are compatible with present data. Additionally, and despite the fact that the total DM abundance turns out to be dominated by the lighter component (the singlet), current and future direct detection experiments may be sensitive to signals from both DM particles.

5

Neutrino masses at two-loop in multi-component dark matter Z5 model

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We proposed a radiative seesaw model where the neutrino masses are generated at two loops. We analyzed the phenomenology of the Z5 model for two-component dark matter and neutrino masses. The Z5 symmetry allows interactions that give rise to processes between dark matter particles that affect their relic densities and their detection, which we studied in detail. In a first approach we considered the scalar sector to be the dark matter candidates.

6

Dark matter production in non-standard cosmologies

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The existence of DM in the universe has been one of the open and more relevant questions in physics and astronomy in the last decades. There is a large number of gravitational evidence about its existence, but no conclusive evidence about its nature as a particle. A worldwide program focused on discovering this particle has been carried out through the previous decades following three major strategies: direct detection, indirect detection, and production at colliders.

Despite the great effort, the DM particle nature remains one of the central mysteries in physics. The important thing is that no particle belongs to the Standard Model (SM) of particle physics with the required properties to explain the observed astrophysical phenomena related to DM.

Until relatively recently the DM models proposed hinged on a standard cosmology basis, however, due to the enormous difficulty present in detecting this particle, new models in different scenarios have been introduced.

According to standard cosmology, the universe in its evolution has gone through a series of stages characterized by definite processes and the domination of one of its components over the rest. As an example, in the standard scenario, the period between the end of inflation and the beginning of BBN is hypothesized to be radiation dominated. However, in this particular case, because of the lack of enough observational information regarding this time, there are no reasons to believe that this assumption is true, and is, therefore, possible that the cosmological history featured, for

example, an additional early matter-dominated epoch due to slow post-inflationary reheating or massive metastable particles that dominated the total energy density.

Even more exotic scenarios that change the expansion history of the universe compared to the standard radiation-dominated case can also be realized. All of them are called non-standard cosmologies, and they can have important consequences for the physics of the early universe. One of particular relevance to this work is the fact that early periods in these scenarios can alter the cosmological abundances of particle species. Specifically, they can have a significant impact on our expectations for the DM relic abundance, since non-standard eras can change the expansion rate of the universe, lead to entropy injections that may dilute the DM relic abundance, or provide a non-thermal production mechanism for DM [1].

This research project aims to develop the phenomenology of a simplified WIMP DM model in a non-standard cosmology, with a long-lived heavy particle (ϕ) sourcing a matter-dominated era in the period ranging from the end of inflation and the onset of BBN, through the introduction of a generic time-dependent rate for the dissipation of matter into radiation [2]. The main goal of this study is to find the parameter space for a WIMP particle in the proposed frame able to account for 85% of DM in the universe and evade the constraints imposed by experiments.

References

[1] Rouzbeh Allahverdi et al. The First Three Seconds: a Review of Possible Expansion Histories of the Early Universe. 6 2020.

[2] Raymond T. Co, Eric Gonzalez, and Keisuke Harigaya. Increasing temperature toward the completion of reheating. Journal of Cosmology and Astroparticle Physics, 2020(11):038–038, nov 2020.

7

Sub-GeV multicomponent dark matter

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In this talk, I will present a dark matter model at the Sub GeV scale where the dark sector is composed of two scalar dark matter particles and a dark photon. All the particles in the dark sector have masses at the Sub-GeV scale. I will show the constraints from relic abundance and detection prospects in upcoming experiments.

8

Enhancing Parameter Exclusion and Extrapolation in Physics Applications with Advanced Machine Learning Techniques: A Phenomenological Perspective

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The burgeoning field of machine learning in physics has proven to be an indispensable tool for constraining parameters and augmenting sensitivities across a range of applications. In this study, we present a modern comparison of diverse methodologies for eliminating parameter space regions within a representative toy model. We further introduce a novel machine learning technique, the Attention Parametric Graph Neural Network model, which demonstrates exceptional performance in both parameter exclusion and extrapolation via sensitivity estimation. Our findings offer valuable insights into the potential of advanced machine-learning approaches for bolstering the efficacy of phenomenological studies which can be applied to constrain dark matter and enhance searches.

9

DM @ LHC: Searches and possibilities

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We examine some of the approaches to search for DM at colliders, and specifically at the LHC. In addition, we develop a more generic approach in order to assess the real possibility of looking for DM at the LHC and how we could confirm a possible discovery.

10

Deep Learning to study neutrino interactions

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High Energy Physics is a pioneer in the usage of deep learning applied to image analysis. Several particle physics experiments around the world are developing novel techniques to classify events and identify particles via deep learning algorithms applied to their event images. Neutrino experiments such as NOvA and DUNE are at the front edge of the field, with results that used deep learning to improve their event reconstruction and particle identification capabilities. With better event classification and particle identification techniques, the field of neutrino interactions advances in the search for lower systematic uncertainties that allow refined experimental results to defy the current theoretical models describing neutrino-nucleus interaction. This presentation summarizes the latests neutrino interaction results and the deep learning techniques used in its achievement.

11

One hundred years of studies of Rotation Curves of Spiral Galaxies

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The standard analysis of the rotation curves of spiral galaxies has led to the proposal of a dark matter component to explain their observed flat behavior. However, alternative models have been proposed to explain this tendency. In this study, we present a comprehensive analysis of the rotation curves in spiral galaxies using various physical theories. Our analysis takes into account recent observations, including the rotation curve of the Milky Way derived from Gaia Data Release 3 (DR3) data. Our objective is to gain a better understanding of the physical processes that govern the velocity behavior in spiral galaxies and to explore alternative explanations for the observed flatness of the rotation curves. Our findings will contribute to ongoing discussions surrounding the nature of dark matter and the dynamics of spiral galaxies.

12

Lepton Flavor Violation from diphoton effective operators

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We consider lepton flavor violating transitions mediated by the diphoton effective interaction $\ell\ell'\gamma\gamma$ and explore which processes can probe it better. Our analysis includes single and double radiative decays, $\ell \to \ell'\gamma(\gamma)$, as well as $\ell \to \ell'$ conversions in nuclei for all possible flavor combinations. We find that using the current upper bounds on the rate for $\ell \to \ell'\gamma$, we can derive model-independent upper limits on the rates for $\ell \to \ell'\gamma\gamma$. We conclude that currently, the best limits for the diphoton effective operators provides from the $\ell \to \ell'\gamma$ process, while the best future sensitivities are from $\mu \to e$ conversion in aluminum and potential $\tau \to \ell\gamma(\gamma)$ searches at Belle II or a Super Tau Charm Facility.

13

BSM physics searches at neutrino oscillation experiments

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Neutrino oscillations, implying massive neutrinos, provided the first direct experimental evidence for physics BSM. In parallel to the 'standard neutrino program' past, current, and future neutrino oscillation experiments have considered, are considering, and will consider, within its physics goals, searches for BSM physics represented by different scenarios. Given the plethora of BSM scenarios and the diversity of neutrino oscillation experiments, in this talk we will focus in some that might be tested in accelerator and/or reactor neutrino experiments. This kind of experiments are expected to improve the precision of the measured three-active neutrino oscillation parameters and to determine the unmeasured ones, as well as to at least provide a hint of where to look for new physics signals or to highly constraint its allowed parameter space.

14

Discussion

15

Discussion

16

Connecting Neutrinos, Majorons and Dark Matter

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Some theoretical models considering heavy neutrinos have postulated a Goldstone known as the Majoron as a viable dark matter candidate. Our study shows the possibility to detect a Majoron in current and future experiments, considering its lifetime close to the age of the universe, and including existing experimental constrains.

17

Hadron production fraction ratios and his relationship with Search for new physics using B→μμ decays

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Rare B meson decays provide a sensitive probe for beyond standard model (BSM) effects. In this talk, some CMS measurements of rare B_{s,d} meson properties will be discussed, including the branching fractions and effective lifetimes.
In addition, the fractions of Bu, Bd, and Bs mesons are denoted by fu, fd, and fs, respectively. Measurements of Bs branching fractions generally rely on ratios to Bu or B0 decay modes, which requires knowledge of fs/fu or fs/fd, respectively. In fact, we will discuss how measurements of the rare decay Bs→μμ, are limited by the uncertainty in fs/fu.

18

TBA