MOCa 2022: Materia Oscura en Colombia

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Book of Abstracts

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A Peccei-Quinn (PQ) symmetry is proposed, in order to generate in the Standard Model (SM) quark sector a realistic mass matrix ansatz with five texture-zeros. Limiting our analysis to Hermitian mass matrices we show that this requires a minimum of 4 Higgs doublets. This model allows assigning values close to 1 for several Yukawa couplings, giving insight into the origin of the mass scales in the SM. Since the PQ charges are non-universal the model features Flavor-Changing Neutral Currents (FCNC) at the tree level. In the model We found a pseudoscalar Nambu-Goldstone which could be a dark matter candidate.

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Flavor violating ℓ_i decay into ℓ_j and a light gauge boson

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The $\ell_i \to \ell_j \chi$ decays, with χ a boson associated to the $U(1)_\chi$ symmetry, have not been described satisfactorily so far for light spin-one χ. In particular, observables exhibited an unphysical divergence in the limit of massless χ, associated with its longitudinal polarizations. Based on gauge symmetry, we show how to correct this issue. To this end, we consider two general models realizing the effective field theory description. Being the LFV is generated either at tree level or at one loop, these processes are well behaved for light m_χ. We discuss the most salient phenomenological consequences and its relevance in the searches for this kind of decays.

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Supermassive black hole formation in scalar field dark matter models

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Scalar-field dark matter (SFDM) halos exhibit a core-envelope structure with soliton-like cores and CDM-like envelopes. Simulations without self-interaction (free-field case) report a core-halo mass relation which can be understood if core and halo obey certain energy or velocity scalings. By extending the core-halo mass relations to include SFDM with self-interaction, in this talk we examine the possibility of supermassive black hole formation in the SFDM model.

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Dark Matter in the Time of Primordial Black Holes

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Hawking evaporation of primordial black holes (PBH) with masses ranging from $\sim 10^{-1}$ to $\sim 10^{9}$ g can generate the whole observed dark matter (DM) relic density. However, a second DM production mechanism, like freeze-out or freeze-in, could have also been active in the early universe. Here we study the interplay of these mechanisms, focusing on the scenario where PBHs dominate the energy density of the universe, leading to a nonstandard cosmological era.

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A new software to compute MSSM squared amplitudes for particle physics and relic density calculations

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The increasing need of numerical predictions for dark matter models is not always easy to satisfy looking at the software available today. With this work, we present a code to compute 2 to 2 squared scattering amplitudes using MARTY, with all the benefits of having a fully open source C++ code to handle. The numerical library generated in this way has been enriched with additional features, aiming at allowing the user to easily include and use such a library in external softwares. We restricted ourselves to the tree-level amplitudes in the MSSM relevant to solve the Boltzmann equation in a freeze-out scenario. Future development of this work will provide a direct interface with SuperIso Relic and the possibility to choose more general models.

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Fermion and scalar two-component dark matter from a Z4 symmetry

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We study a two-component dark matter model in which the dark matter particles are a singlet fermion (ψ) and a singlet scalar (S), both stabilized by a single Z4 symmetry. The model is remarkably simple, with its phenomenology determined by just five parameters: the two dark matter masses and three dimensionless couplings. In fact, S interacts with the Standard Model particles via the usual Higgs-portal, whereas ψ only interacts directly with S, via the Yukawa terms ψc(ys + ypγ5)ψ S. We consider the two possible mass hierarchies among the dark matter particles, MS < Mψ and Mψ < MS , and numerically investigate the consistency of the model with current bounds. For dark matter masses below 1.3 TeV or so, we find that the model not only is compatible with all known constraints, but that it also gives rise to observable signals in future dark matter experiments. Interestingly, both dark matter particles may be observed in direct detection experiments while the most relevant indirect detection channel is due to the annihilation of ψ. We also argue that this setup can be extended to other ZN symmetries and additional dark matter particles.

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Multicomponent dark matter: recent developments

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In this talk I will discuss some recent developments concerning scenarios of multi-component dark matter based on a single ZN symmetry.

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Scalar potential analysis of the Z5 multi-component dark matter model

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In recent years the multi-component scalar dark matter models with discrete symmetries $\mathbb{Z}_N$ has been widely studied in the literature. Among them, the $\mathbb{Z}_5$ model proposes two complex fields that transform as singlets under the gauge group of Standard Model. The model has eleven free parameters that must be restricted. In that sense, the main purpose of this research is to develop an detailed analysis of the scalar potential with the objective to establish the perturbative unitarity, vacuum stability and positivity conditions, and finally to determine the viable parameter space of the model.

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Effective Dirac Neutrino Mass Operator in the Standard Model With a Local Abelian Extension

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We present 48 types of solutions to the anomaly cancellation conditions of local Abelian extensions of the Standard Model (SM) with right-handed SM-singlet chiral fermions. At least two of them acquire effective light Dirac neutrino masses, while the others get heavy masses from the spontaneous symmetry breaking of the local Abelian symmetry, forming a dark sector with multi-component and multi-generational fermionic dark matter. The corresponding effective Dirac neutrino mass operator can be realized at tree-level or radiatively by introducing extra scalars, and in some cases after imposing extra scotogenic conditions.The Dirac Zee model with Dirac fermionic dark matter is presented as an example of model where the neutrino and dark matter phenomenology are basically independent of each other.

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Complementarity of experiments in probing the non-relativistic effective theory of dark matter-nucleon interactions

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The non-relativistic effective theory of WIMP-nucleon interactions depends on 28 coupling strengths. Due to the vast parameter space of the effective theory, most direct detection experiments interpret the results of their searches assuming that only one of the coupling strengths is non-zero. On the other hand, dark matter models generically lead in the non-relativistic limit to several interactions which interfere with one another, therefore, the published limits cannot be straightforwardly applied to model predictions. We present a method to determine a rigorous upper limit on the WIMP-nucleon interaction strength including all possible interferences among operators. We illustrate the method using the null search results from the XENON1T and the PICO collaborations; for some interactions, the limits on the coupling strengths are relaxed up to one order of magnitude. We also present a method that allows to combine the results from different experiments, thus exploiting the synergy between different targets in exploring the parameter space of WIMP-nucleon interactions.

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Dark matter from dark photon signal classification at DUNE near detector with machine learning

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We study a scalar dark matter (DM) model with two DM species coupled to the Standard Model (SM) particles via a sub-GeV dark photon. The two DM candidates can be produced at fixed-target experiments a la Beam- Dump. We used machine learning techniques to distinguish signal from background and explored the potential reach in the sensitivity of DUNE near detector.

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Observational signatures of compact dark stars

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If the dark matter particle has self-interactions, it is generically expected that a fraction of the dark matter of the Universe would be in the form of compact dark stars, that could be detected as microlensing events. Here we consider the possibility that the dark matter not only interacts with itself, but also with the proton. If this is the case, protons from the interstellar medium could be captured by the compact dark star and eventually thermalize with it. We argue that the thermal radiation emitted by the captured protons could be intense enough to be detected by gamma-ray or X-ray telescopes, thus providing an additional avenue to indirectly detect dark matter.

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