MOCa 2o2o: Materia Oscura en Colombia

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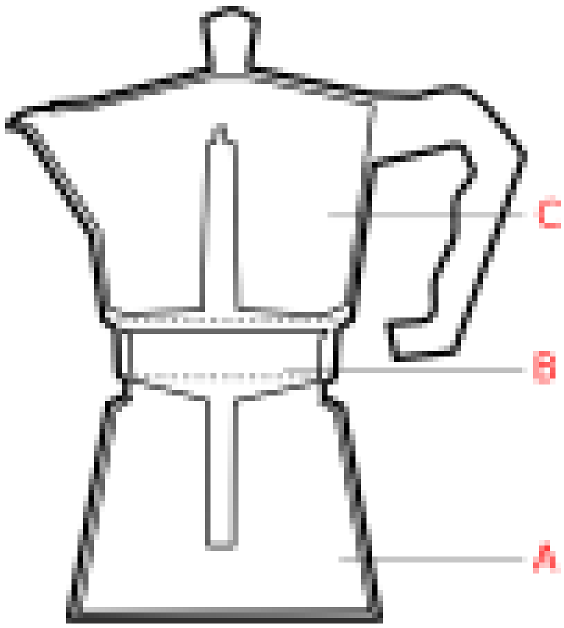

Book of Abstracts

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Flavored axions and the flavor problem

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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. We calculate the FCNC couplings of the most general low-energy effective Lagrangian for the axion in a procedure valid for an arbitrary number of Higgs doublets. Finally, we report the allowed region in the parameter space obtained from the measurements of branching ratios of semileptonic meson decays. By choosing conveniently the
parameters of our model, it is possible to adjust the recently reported XENON1T anomaly. Dark matter interpretations for the axion will be also discussed.

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Non-particle dark matter from Hubble parameter

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The measurements of the Hubble parameter using the cosmic microwave background radiation appear to be inconsistent with the measurements of this parameter using Cepheid variable stars. This inconsistency may be a result of using the ΛCDM cosmology, which assumes pressureless dark matter, in extrapolating the data from the recombination time to the present time. We show that both measurements are consistent if dark matter satisfies an equation of state in which the pressure p and the energy density ϵ are related by $p = w\epsilon$ with a negative value of w. The data give $w \approx -0.01$. The negative value of w indicates that dark matter would not be formed by particles, which is consistent with the lack of experimental evidence for them.

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Dynamical Symmetry Breaking and Fermion Mass Hierarchy in the Scale-Invariant 3-3-1 Model

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We propose an extension of the Standard Model (SM) based on the SU(3)C⊗SU(3)L⊗U(1)X (3-3-1) gauge symmetry and scale invariance. Maintaining the main features of the so-called 3-3-1 models, such as the cancellation of gauge anomalies related to the number of chiral fermion generations, this model exhibits a very compact scalar sector. Only two scalar triplets and one singlet are necessary and sufficient to break the symmetries dynamically via the Coleman-Weinberg mechanism.

With the introduction of an Abelian discrete symmetry and assuming a natural hierarchy among the vacuum expectation values of the neutral scalar fields, we show that all particles in the model can get phenomenologically consistent masses. In particular, most of the standard fermion masses are generated via a seesaw mechanism involving some extra heavy fermions introduced for consistency. This mechanism provides a partial solution for the fermion mass hierarchy problem in the SM. Furthermore, the simplicity of the scalar sector allows us to analytically find the conditions for the potential stability up to one-loop level and show how they can be easily satisfied. Some of the new particles, such as the scalars H, H± and all the non-SM vector bosons, are predicted to get masses around the TeV scale and, therefore, could be produced at the high-luminosity LHC. Finally, we show that the model features a residual symmetry which leads to the stability of a heavy neutral particle; the latter is expected to show up in experiments as missing energy.

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Sterile Neutrino Dark Matter via Secret Neutrino Interactions

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In this talk, I will present the anatomy of production mechanisms for sterile neutrino dark matter, a keV-scale gauge-singlet fermion that mixes with active neutrinos, in the presence of new interactions among active neutrinos. These new interactions allow sterile neutrinos to make up all the DM while safely evading all current experimental bounds. The existence of these new neutrino interactions may manifest itself in next-generation experiments, including DUNE.

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Boosting Freeze-in through Thermalization

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If the interaction rates between the visible and the dark sectors were never strong enough, the observed dark matter relic abundance could have been produced in the early Universe by non-thermal processes. This is what occurs in the so-called freeze-in mechanism. In the simplest version of the freeze-in paradigm, after dark matter is produced from the standard model thermal bath, its abundance is frozen and remains constant. However, thermalization and number-changing processes in the dark sector can have strong impacts, in particular enhancing the dark matter relic abundance by several orders of magnitude. Here we show that this enhancement can be computed from general arguments as the conservation of energy and entropy, independently from the underlying particle physics details of the dark sector. We also note that this result is quite general, and applies to FIMP production independently of being UV- or IR-dominated.

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Some phenomenological consequences of neutrino emission from primordial black holes

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Hawking radiation offers a unique method of neutrino production, unlike any weak interaction process. In fact, black hole evaporation depends on whether neutrinos are Dirac or Majorana, providing a different phenomenology in each case. If neutrinos are Dirac particles, the emission of the light right-handed states does not suffer from the helicity suppression present in weak interactions. Hence, it is possible to have a significant fraction of such states as relics from the Early Universe. On the other hand, if neutrinos are Majorana, heavy right-handed states like those appearing in the seesaw mechanism can be produced by a black hole, altering the thermal leptogenesis, and thus the baryon asymmetry. In this talk, we will explore these possibilities.

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The Z5 model of two-component dark matter

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In this talk we present the phenomenology of the Z5 model for two-component dark matter. This model, which can be seen as an extension of the well-known singlet scalar model, features two complex scalar fields–the dark matter particles–that are Standard Model singlets but have different charges under a Z5 symmetry. The interactions allowed by the Z5 give rise to novel processes between the dark matter particles that affect their relic densities and their detection prospects.
Dark matter masses below the TeV are still compatible with present data, and current and future direct detection experiments may be sensitive to signals from both dark matter particles.

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Bound States and dark matter

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Ordinary matter is in the form of bound states. The simple example is hydrogen, which is a bound state of one proton and one electron. Another example is the proton itself, which is a bound state of the elementary particles of QCD. In the light of this, it is natural to ask whether dark matter is made of bound states or if it is an elementary particle that can form them.
This talk is devoted to the first possibility, that is, I will assume that dark matter itself is a bound state and I will discuss the phenomenological consequences associated to its finite size.

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Dirac neutrinos with Dark photon portal for Dark matter

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Majoron Dark Matter and Neutrino Masses In The Type 1 Seesaw Mechanism

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In this talk we introduce the neutrino mass problem of the Standard Model of particle physics. Then, we analyze how to generate these masses by introducing right-handed Majorana singlets in the type 1 Seesaw mechanism framework. Afterwards, we explain the origin of these masses through the spontaneous symmetry breaking of a global U(1) symmetry, which introduces a new scalar singlet with a massive Goldstone mode, referred to as the Majoron. We conclude the talk by showing some preliminary results on Majoron production at the LHC in two specific channels.

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Polar ring structures in simulations of minor mergers of galaxies.

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Substructures formed during the accretion of mass in the process of structure and galaxy formation can be used as a test to study the presence and nature of dark matter.
In this particular talk we study the formation of polar ring galaxies via minor mergers of galaxies. We used N-body + hydrodynamics simulations to reproduce the dynamics of the observed system AM 2229-735 that is a minor merger whose interaction signals are those of a progenitor for a polar ring galaxy. We used the observational information of the system to get initial conditions for the orbit and numerical realizations of the galaxies to run the simulations. Our simulations reproduce the global characteristics of interaction observed in the system such as arms and a material bridge connecting the galaxies. As a merger remnant, we found a quasi-stable and self-gravitating planar tidal stream with dark matter, stars, and gas orbiting in a plane approximately perpendicular to the main galaxy disc leading in the future to a polar ring galaxy. We studied the dynamical conditions of the polar structure and found evidence suggesting that this kind of merger remnant can settle down in a disc-like structure with isothermal support, providing inspiring evidence about the process of formation of galactic discs and providing a potentially independent scenario to study the presence of dark matter in this kind of galaxies.

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The SENSEI Experiment: An Ultrasensitive Search for Sub-GeV Dark Matter

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Devices with low energy thresholds are one of the main pillars for the direct detection of dark matter, and tremendous progress has been made in the past few years in probing dark matter with sub-GeV masses. The SENSEI (Sub-Electron Noise Skipper Experimental Instrument) Collaboration has pioneered the silicon-based Skipper-Charge Coupled Device (CCD) technology capable of detecting electron recoils from dark matter interactions with sub-electron-noise precision and has already achieved world-leading sub-GeV dark matter results. Over the past year, SENSEI has been testing, characterizing, and taking science data with new SkipperCCDs, which demonstrate the excellent performance and promise of this technology for sub-GeV dark matter searches. This talk will describe these developments and recent dark matter search results. The current status and future plans of SENSEI will also be discussed, including the status of installing at SNOLAB a detector consisting of about 100-grams of Skipper-CCDs.

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Chiral Gravitational Waves and Primordial Black Holes in Axion Inflation

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We consider an UV-protected Natural Inflation scenario involving Chern-Simons-like interactions between the inflaton and some beyond the Standard Model gauge fields. The accelerated expansion of the Universe is supported by a combination of a gravitationally-enhanced friction sensitive to the scale of inflation and quantum friction effects associated with the explosive production of gauge fluctuations.
The synergy of these two velocity-restraining mechanisms allows for: i) Natural Inflation potentials involving only sub-Planckian coupling constants, ii) the generation of a dark matter component in the form of primordial black holes, and iii) a potentially observable background of chiral gravitational waves at small scales.

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Axions and Cosmic Strings

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Axions have for some time been considered a plausible candidate for dark matter. They can be produced through misalignment, but it has been argued that when inflation occurs before a Peccei-Quinn transition, appreciable production can result from cosmic strings. This has been the subject of extensive simulations. But there are reasons to be skeptical about the possible role of axion strings. We review and elaborate on these questions, and argue that parametrically strings are already accounted for by the assumption of random misalignment angles.

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Neutron star constraints on dark matter

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Due to their extreme density and low temperature, compact objects such as old neutron stars (NS) are efficient probes to unveil interactions between standard model and dark matter (DM) particles. From elastic scatterings on NS matter, DM can get gravitationally trapped by the star. The in-falling DM unavoidably transfers heat to the NS and can heat up old NS up to 1700 K. Moreover, if DM is symmetric, its annihilations inside the NS also heat up old NS to 2400 K, leading to an infrared black body spectrum that is in principle within range of future infrared telescopes. However, such a prospect depend critically on whether captured dark matter thermalizes with the NS core within its lifetime. In this talk, I will discuss the phenomenology of DM thermalization in NS via scattering on fermi-degenerate non-relativistic neutrons and relativistic electrons carefully accounting for the respective kinematics.

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Unimodular Gravity and diffusion processes in the dark sector: a possible solution to the H0 tension

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In this talk, we will review some phenomenological diffusion models within the gravitational framework of Unimodular Gravity. We will show that, when regarding non-gravitational interactions between cold dark matter and an effective cosmological constant, it is possible to address one of the modern cosmological problems: the discrepancy between the early and late time inferred value of the current Hubble parameter, H0. Finally, we will impose some constraints on the main diffusion parameters to study the viability of these models.

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Probing Compressed Higgsino Models via Vector Boson Fusion Processes at the LHC

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The identity of Dark Matter (DM) is one of the most active topics in particle physics today. Supersymmetric models, theoretical extensions of the Standard Model (SM), provide possible explanations to the particle nature of DM. Considering R-parity conservation in supersymmetric models such as the Minimal Supersymmetric Standard Model (MSSM) provides a natural DM candidate: the lightest neutralino ($\tilde{\chi}$ 01). Most of the theoretical models have considered $\tilde{\chi}$ 01 as a Bino or Wino particle. However, the Higgsino-like $\tilde{\chi}$ 01 is also an alternate candidate. In the Higgsino search proposed, the Vector Boson Fusion (VBF) topology is used to overcome the limited experimental sensitivity in compressed mass spectra regions. The presentation explores the use of VBF topology to target DM production of Higgsino-like scenarios in compressed mass spectra regions at the LHC.