16th MultiDark Workshop -Program
Abstracts

Particle Physics, LHC, and Dark Matter, day 25 afternoon

1) Heinemeyer, Sven
IFT UAM-CSIC

SUSY Higgs mass and DM predictions

2) Cepedello, Ricardo
IFIC CSIC-UV

Radiative neutrino masses with Dark Matter

Neutrino masses and dark matter unarguably point toward new physics beyond the Standard Model. In this talk, I will discuss scenarios where the radiative generation of neutrino masses is mediated by a dark matter candidate. I will show from a symmetry perspective how the smallness of neutrino masses, the Majorana or Dirac nature of neutrinos and the stability of dark matter can be linked together.

3) Centelles, Salvador
IFIC CSIC-UV

Dirac neutrino mass models and connection with Dark Matter

B-L symmetry is conserved in the Standard Model as an accidental symmetry and it is very well stablished form the experimental point of view. However, we do not know if new physics breaks B-L and, if it does, how. This is a crucial question since many different new physics scenarios can arise from the breaking pattern of B-L. Here we will explore some of the many possible breaking patterns and relate this symmetry with appealing physics scenarios such as neutrino masses, dark matter stability and proton decay.

Cosmology, day 26 morning

1) Karciauskas, Mindaugas
UCM

Inflaton-Higgs Interactions and Direct Searches at LHC

The current data favour metastability of the electroweak (EW) vacuum, which poses a number of cosmological challenges. We suggest a novel solution which does not employ any extra fields beyond the inflaton. We show that the Higgs mixing with an inflaton can lead to a stable EW vacuum. A trilinear Higgs–inflaton coupling always results in such a mixing and it is generally present in realistic models describing the reheating stage correctly. We find that cosmological constraints on this coupling are weak and an order one mixing is possible. In this case, the model is effectively described by a single mass scale of the EW size, making it particularly interesting for direct LHC searches.

2) García García, Marcos
IFT UAM-CSIC

Cosmology with a Master Coupling in Flipped SU(5)

We propose a complete cosmological scenario based on a flipped SU(5) × U(1) GUT model that incorporates Starobinsky-like inflation, taking the subsequent cosmological evolution carefully into account. Within it, a single master coupling controls the neutrino masses, the baryon asymmetry of the universe, the dynamics of the GUT transition, the inflaton decay rate and reheating, and the non-thermal abundance of cold dark matter. I will in particular focus on the post-inflationary dynamics, and the correlation between the CDM abundance and the baryon asymmetry.

3) Fernández de Salas, Pablo
Oskar Klein Centre for Cosmoparticle Physics - Stockholm University

The local DM density from the Milky Way's rotation curve using Gaia DR2

The local density of dark matter (DM) is an important quantity. On the one hand, its value is needed for DM direct detection searches. On the other hand, a precise and robust determination of this quantity would help us to learn about the shape of the DM halo of our Galaxy, which plays an important role in DM indirect detection searches, as well as in many studies in astrophysics and cosmology. Among the different methods available to determine the local DM density, we can analyse the rotation curve of the Milky Way. In this talk, I will present the results of a study of the Milky Way's rotation curve using data obtained from the second data release (DR2) of the ESA/Gaia mission. Despite the precision of the Gaia DR2 data, I will discuss the limitations of the rotation curve method in order to determine the local DM density, whose estimated value depends on the assumed Galactic distribution of baryons. Finally, I will compare our estimated local DM density, obtained under reasonable assumptions using the rotation curve's method, with other determinations also using Gaia DR2 data but with different methods.

Cofee Break

4) Vargas Lopes, José
CENTRA, IST, Universidade de Lisboa

Stars and Dark Matter at the center of the Milky Way

The study of dark matter captured inside stars has proved to be a viable indirect search strategy complementary to other direct searches. In this context, only a fraction of the rich diversity of physics found in different types of stars has been explored, with most studies mainly focused in the Sun. In this work we looked to the center of the galaxy and studied the imprint of dark matter particles in two completely different types of stars: low mass main-sequence stars and Red Clump (helium burning) stars. We found that the scattering interactions between baryons and dark matter particles within the central region of these stars can result in effects such as the slowdown of the nuclear burning rate or the suppression of core convection, both of which can have an important impact on the evolution and asteroseismology of the star.

5) Mostoghiu, Robert Adriel
UAM

The evolution of cluster density profiles

Recent numerical studies of the dark matter density profiles of massive galaxy clusters (Mhalo > 10^15 Msun) show that their median radial mass density profile remains unchanged up to z>1, displaying a highly self-similar evolution. We verify this by using the data set of the \"The Three Hundred" project, i.e. 324 cluster-sized haloes as found in full physics hydrodynamical simulations. We track the progenitors of the mass-complete sample of clusters at z=0, and find that their median shape is already in place by z=2.5. However, selecting a dynamically relaxed subsample (~16 per cent of the clusters), we observe a shift of the scale radius r_s towards larger values at earlier times. Classifying the whole sample by formation time, this evolution is understood as a result of a two-phase halo mass accretion process. Early-forming clusters -- identified as relaxed today -- have already entered their slow accretion phase, hence their mass growth occurs mostly at the outskirts. Late-forming clusters -- which are still unrelaxed today -- are in their fast accretion phase, thus the central region of the clusters is still growing. We conclude that the density profile of galaxy clusters shows a profound self-similarity out to redshifts z~2.5. This result holds for both gas and total density profiles when including baryonic physics, as reported here for two rather distinct sub-grid models.

6) Lacroix, Thomas
IFT UAM-CSIC

Looking for ultralight dark matter near supermassive black holes

Ultralight dark matter (ULDM) has gained interest in the past few years both as an alternative to thermally produced dark matter (DM) candidates, and as a promising way to alleviate possible small-scale tensions within the cold DM paradigm, for masses between 10^-22 and 10^-21 eV. Although this particular mass range is now in tension with cosmological constraints, more general ULDM candidates still comprise the lightest possible DM candidates and as such warrant dedicated studies. Now, measurements of the dynamical environment of supermassive black holes (SMBHs) have been steadily accumulating, becoming both abundant and precise. In this presentation, I will show how we can use such measurements to look for ULDM, which is predicted to form dense cores (“solitons”) in the center of galactic halos. More specifically, it is possible to search for the gravitational imprint of an ULDM soliton on stellar orbits near the supermassive black hole Sgr A* at the center of the Milky Way, and by combining stellar velocity measurements with Event Horizon Telescope imaging of the SMBH M87* in the M87 galaxy. I will discuss the resulting constraints we obtain, as well as the associated theoretical uncertainties.

7) Álvarez Luna, Clara
UCM

On the abundance and possible signals of topological dark matter

In this work, we explore the possibility of topological defects as viable dark matter candidates. The non-thermal production of magnetic monopoles by a phase transition is studied. The Kibble mechanism is analyzed, concluding that it is not a good approach to estimate their abundance and studying the corrections of the Kibble-Zurek model. We also study the effect of monopoles annihilation within this framework. The result of this analysis is that monopoles with a mass around the PeV provide a density compatible with PLANCK observations of the present dark matter density In addition, recent observations of high energy neutrinos by IceCube show an spectrum that is not compatible with a power law that would be expected in a standard astrophysical scenario. We study the possibility that a decaying dark monopole with a mass in the PeV range provides a

promising interpretation of the observed spectrum.

8) Villarubia, Héctor
UCM

Cosmology with a tilted dark sector

One of the fundamental assumptions of the standard ΛCDM cosmology is that, on large scales, all the matter-energy components of the Universe share a common rest frame. This seems natural for the visible sector, that has been in thermal contact and tightly coupled in the primeval Universe. The dark sector, on the other hand, does not have any non-gravitational interaction known to date and therefore, there is no a priori reason to impose that it is comoving with ordinary matter. In this work we explore the consequences of relaxing this assumption and study the cosmology of non-comoving fluids. We show that it is possible to construct a homogeneous and isotropic cosmology with a collection of fluids moving with non-relativistic velocities. Our model extends ΛCDM with the addition of a single free parameter β_0, the initial velocity of the visible sector with respect to the frame that observes a homogeneous and isotropic universe. This modification gives rise to a rich phenomenology, while being consistent with current observations for $\beta_0<1.6\times 10^{-3}$ (95% CL). Among the observable effects we find: sizeable modifications in the density-velocity and density-lensing potential cross-correlation spectra for matter, violations of CMB statistical isotropy and production of vorticity and cosmological magnetic fields through new couplings between scalar and vector modes.

Indirect detection: gamma rays and cosmic rays, day 26 afternoon

1) Sánchez-Conde, Miguel Ángel
IFT UAM-CSIC

Gamma-rays and cosmic-rays working group: summary of activities

2) Daniel Kerszberg
IFAE-BIST

Update on dark matter searches with the MAGIC telescopes

In this talk, I will report on recent results and ongoing activities related to the indirect search for dark matter with the MAGIC experiment. MAGIC is a stereoscopic system of two Imaging Atmospheric Cherenkov Telescopes located on the Canary island of La Palma that detects gamma-rays from 30 GeV to 50 TeV. MAGIC is actively conducting searches for gamma-ray signals from WIMP dark matter annihilation and decay towards various targets such as the Galactic halo, dwarf spheroidal galaxies and clusters of galaxies. In particular I will present a new method for probing dark matter decays in the Galactic halo and report on recent efforts from different gamma-ray experiments including MAGIC to combine their data in the search for dark matter annihilation in the direction of dwarf spheroidal galaxies.

3) Gammaldi, Viviana
IFT UAM-CSIC
Dark matter searches in dwarf irregular galaxies with Fermi LAT

4) Miener, Tjark
UCM

LikelihoodCombiner - Code framework to combine likelihoods from different experiments

The nature of dark matter (DM) is still an open question for modern physics. In the particle DM paradigm, this elusive kind of matter cannot be made of any of the known particles of the Standard Model (SM). Weakly interacting massive particles (WIMPs) are one of the most favored candidates for DM with the expected mass range of ~10 GeV to a few TeV. Gamma-ray observatories could potentially detect DM indirectly, by observing secondary products of its annihilation into SM particles. In order to obtain better limits on the annihilation cross-section for DM particle masses, datasets of different gamma-ray experiments are combined. The LikelihoodCombiner is a code framework under active development to combine likelihoods from different experiments and obtain combined limits. Neither event lists nor instrumental response functions have to be shared by the collaborations or inputed into the LikelihoodCombiner package.

Cofee Break

5) Aguirre-Santaella, Alejandra
IFT UAM-CSIC

The viability of low-mass subhalos as targets for gamma-ray dark matter searches

In this talk, we present our studies of the discovery potential of low-mass Galactic dark matter (DM) subhalos for indirect searches of DM. In particular, we analyzed the properties of DM halo substructure in a galaxy like our own. To do so, we have used data from the Via Lactea II (VL-II) N-body cosmological simulation, that resolves subhalos down to one million solar masses. First, we characterized the abundance, distribution and structural properties of the VL-II subhalo population. Then, we repopulated the original simulation with millions of subhalos of masses down to four orders of magnitude the nominal VL-II particle resolution. In a final step, we computed mean subhalo DM annihilation fluxes for the entire subhalo population, for which we created hundreds of VL-II realizations. Our results show that low-mass Galactic subhalos (including those not massive enough to retain stars/gas) may yield annihilation fluxes comparable to those expected from other, more acknowledgeable DM targets like dwarf galaxies. Thus, small subhalos may play a very relevant role in current and future indirect DM searches such as those performed in gamma rays from both the ground and space.

6) Coronado-Blázquez, Javier
IFT UAM-CSIC

Sensitivity of the Cherenkov Telescope Array to dark matter subhalos

In this talk, we present Cherenkov Telescope Array (CTA) prospects for WIMP dark matter (DM) indirect detection through very-high-energy gamma rays originated from DM annihilations in low-mass Galactic DM subhalos. Given their masses, these are not expected to host gas/stars at all and would thus appear in the sky as unidentified gamma-ray sources (unIDs). By using the latest instrumental response functions available, we simulate CTA observations under different array configurations and pointing observation strategies, such as the scheduled CTA Extragalactic Survey. We then predict the sensitivity of CTA to dark subhalos for such scenarios, for which we also use results from N-body cosmological simulations to predict subhalo annihilation fluxes. In the absence

of a DM signal, we obtain limits to the DM annihilation cross section as a function of the mass of the WIMP. We do so by also studying and proposing the best type of observation strategy that would be needed in order to derive the best achievable constraints. Our prospects are competitive to those expected for other DM targets, such as dwarf galaxies and galaxy clusters.

7) Pérez Romero, Judit
IFT UAM-CSIC

CTA sensitivity to WIMP-induced gamma-ray signals from galaxy clusters

I will present an update of the ongoing effort for estimating the sensitivity of CTA to detect WIMP-induced gamma-ray emission from galaxy clusters. Following state-of-the-art studies of the different X-rays properties of the clusters, we have selected a preliminary target sample constituted by 52 nearby objects. This sample includes the Perseus galaxy cluster, which has been probed as one of the most promising ones for CTA according to previous works. For each selected cluster, we perform an up-to-date modelling of the dark matter content and simulate the corresponding expected induced gamma-ray signal. Including the most recent CTA instrument response functions, we compute the expected CTA sensitivity using a likelihood maximization analysis combining spatial and spectral templates of both the cosmic-ray and dark-matter induced gamma rays. The final goal is to show the sensitivity of CTA to discover, for the first time, diffuse TeV gamma rays in galaxy clusters. Even in the case of not predicting a detection, we will show that CTA can provide stringent constraints on TeV dark matter annihilation into gamma-rays, which are competitive to other targets and DM probes.

Direct Detection, day 27 morning

1) Martínez Pérez, María
UNIZAR

Search for annual modulation with ANAIS-112: two years results

2) Coarasa, Ivan
UNIZAR

ANAIS-112 sensitivity in the search for dark matter annual modulation

3) López Asamar, Elias
LIP-Coimbra

Status of the LZ experiment

Cofee Break

Indirect detection: neutrinos and high-energy cosmic rays, day 27 morning

1) Gozzini, Sara Rebeca
IFIC CSIC-UV

Search for dark matter with the ANTARES and KM3NeT neutrino telescopes

One of the most pressing tasks in physics today is the search for dark matter, whose nature is still unknown despite it makes the majority of the matter content in the Universe. If dark matter is made of particles, they are outside the Standard Model. In the last decades, several of their properties were learned, but they are still quite unbound. A multi-front attack to the problem is needed, as it is impossible to know in advance which is the best experimental strategy to look for dark matter. Neutrino telescopes have interesting advantages in this endeavour. It is expected that dark matter particles would accumulate in astrophysical bodies like the Sun or the Galactic Centre and their final annihilation/decay products would include neutrinos. In the case of the Sun, it would be a very clean signal, since no relevant astrophysical background is expected. In the case of the Galactic Centre, the results of the ANTARES neutrino telescope provide constraining limits for large masses of dark-matter candidates. In this talk, the most recent results obtained by ANTARES for the search of neutrinos due to dark-matter annihilation in different astrophysical objects are reviewed. The perspectives for its successor, KM3NeT, already in construction, are also shown.

2) Pastor, Sergio
IFIC CSIC-UV

Clustering of relic neutrinos in the Milky Way

Neutrino oscillations have shown that these weakly interacting particles have a mass different from zero, although cosmology points towards smaller values for their masses than previously expected. Despite the smallness of their mass, relic neutrinos coming from the time of their decoupling might cluster under strong gravitational potentials, such as the one of our galaxy, leading to an overdensity of such neutrinos in our surroundings. This can be helpful for future experiments' aiming at detecting relic neutrinos, like PTOLEMY. I will discuss an update on the gravitational clustering of relic neutrinos in the Milky Way, showing that the expected overdensity is unfortunately lower than desired.

3) Gariazzo, Stefano
IFIC CSIC-UV

Neutrino physics with the PTOLEMY project

The Cosmic Neutrino Background (CNB) is a prediction of the standard cosmological model, but it has been never observed directly. Several methods of direct detection for the CNB have been proposed in the past and the most promising one is currently adopted to develop the PTOLEMY proposal. I will review the physics reach of PTOLEMY, mostly from the point of view of neutrino physics.

4) Ternes, Christoph Andreas
IFIC, CSIC-UV

Non standard neutrino oscillation physics at DUNE

I will start giving a short introduction on the upcoming DUNE experiment. Next I will discuss several of the new physics scenarios at DUNE. In particular I will talk about the sensitivity to CPT invariance and Lorentz violation. Finally I will talk about the capability of DUNE (in combination with JUNO) to detect quasi-Dirac neutrinos.

5) Pablo Martínez Miravé
IFIC, CSIC-UV

Sterile Neutrinos and Modified Dispersion Relations

In this talk, I address the implications of sterile neutrinos with modified dispersion relations and their potential to account for the anomalous results reported by some neutrino oscillation experiments. Several sources of inconsistencies with the experimental data arise in these family of models as a consequence of additional energy dependencies in the mass-splittings and mixing angles.