Light Dark World 2023

Report of Contributions

Contribution ID: **1** Type: **not specified**

Direct detection of light dark matter from evaporating primordial black holes

Thursday, September 21, 2023 12:20 PM (10 minutes)

Light Dark Matter has recently gained a lot of attention. Generally, direct detection of sub-GeV Dark Matter is challenging since it induces low recoil energies. The problem is solved by considering light Dark Matter with considerable kinetic energies. In this talk, we point out that Primordial Black Hole evaporation is a source of boosted light dark Matter with energies of tens to hundreds of MeV. Considering XENON1T data, we constrain the mixed parameter space of Primordial Black Holes and sub-GeV Dark Matter.

Authors: CALABRESE, Roberta; CHIANESE, Marco (University of Naples Federico II); SAVIANO, Ninetta; FIORILLO, Damiano F. G.

Presenter: CALABRESE, Roberta

Contribution ID: **2** Type: **not specified**

Forbidden Conformal Dark Matter at a GeV

Wednesday, September 20, 2023 10:00 AM (30 minutes)

In this talk, I will present a new model of DM where the DM is a composite of a spontaneously broken conformal field theory. The DM is a thermal relic with its abundance determined by the freeze-out of annihilations to dilatons, the Goldstone boson of broken conformal symmetry. If the dilaton is heavier than the DM this is an example of forbidden DM. I will present a fully realistic model that describes this DM candidate and its interactions with ordinary particles with masses in the 0.1-10 GeV range. The conformal phase transition is supercooled and strongly first-order. It can source large stochastic gravitational wave signals consistent with those recently observed at pulsar timing arrays like NANOGrav. The majority of the viable parameter space will be probed by future detectors designed to search for long-lived particles, including most of the region favored by the NANOGrav signal. The rest of the parameter space can be probed at future direct detection experiments.

Author: LEE, Seung J. (Korea University)

Presenter: LEE, Seung J. (Korea University)

Contribution ID: **3** Type: **not specified**

Light dark matter detection in the lab: new tools and new ideas

Wednesday, September 20, 2023 9:00 AM (30 minutes)

I will discuss some possible avenues to hunt for sub-GeV dark matter in the lab. Specifically, for dark matter in the MeV to GeV range, I will discuss the possibility of employing the so-called Migdal effect in semiconductors. For dark matter in the keV to MeV range, instead, I will discuss the possibility of taking advantage of collective excitations in superfluid He-4 and anti-ferromagnets. In all these instances, I will show how the most convenient way of tackling the problem is through an effective field theory approach.

Author: ESPOSITO, Angelo (Sapienza University of Rome)

Presenter: ESPOSITO, Angelo (Sapienza University of Rome)

Contribution ID: **4** Type: **not specified**

Astrophysical axion searches using neutron stars

Tuesday, September 19, 2023 3:00 PM (30 minutes)

In this talk I will discuss a series of novel ideas and searches being developed to indirectly look for the existence of axions in the magnetospheres of neutron stars. The large magnetic fields and the dilute plasma surrounding neutron stars can dramatically enhance the electromagnetic interactions of axions, giving rise to a variety of signatures in the radio band, including: narrow spectral lines centred about the axion mass, broadband radio emission, short-term and longer-term transient events, and nulling of the pulsar's radio emission. I will highlight the status of current searches, future prospects, and open questions that need to be addressed as we move toward the next generation of radio telescopes.

Author: WITTE, Samuel

Presenter: WITTE, Samuel

Contribution ID: **5** Type: **not specified**

Sub-GeV Dark Matter at large neutrino detectors

Wednesday, September 20, 2023 11:00 AM (20 minutes)

I will review our proposal to observe sub-GeV Dark Matter upscattered by cosmic rays at large neutrino detectors like Super- and Hyper-Kamiokande, DUNE, KamLAND and JUNO. I will show that this technique tests genuinely new parameter space, allowed both by theoretical consistency and by other direct detection experiments, cosmology, meson decays and the LHC. I will present novel strong constraints coming from DM produced in atmospheric showers, and discuss new ideas to possibly test sub-GeV DM at even larger detectors like KM3NeT.

Author: SALA, Filippo (University of Bologna and INFN)

Presenter: SALA, Filippo (University of Bologna and INFN)

Contribution ID: **6** Type: **not specified**

Neutrinos in Cosmology

Thursday, September 21, 2023 3:00 PM (30 minutes)

Neutrinos are ubiquitous in cosmology and they represent a relevant component of the energy density of the Universe across its entire history. This fact makes cosmology a key arena to understand the properties of the most elusive particles in the Standard Model. I will review the main cosmological implications of neutrinos including their impact on Big Bang Nucleosynthesis and the Cosmic Microwave Background. I will also discuss current cosmological constraints on various neutrino properties including their mass within the LCDM model and several of its extensions.

Author: ESCUDERO ABENZA, Miguel (CERN)

Presenter: ESCUDERO ABENZA, Miguel (CERN)

Contribution ID: **7** Type: **not specified**

Light vector bosons and the weak mixing angle in the light of new reactor-based CEνNS experiments

Thursday, September 21, 2023 11:20 AM (10 minutes)

After the first observation of coherent elastic neutrino-nucleus scattering (CEνNS), further experiments with different technologies have been established and the question arises how this signal can be further exploited for a variety of investigations in the future. In this context, nuclear reactors with their intense emission of low-energy antineutrinos in combination with high-purity germanium detectors have already shown their potential for CEνNS studies and represent a scalable technology for future precision experiments. Such measurements are of interest because deviations from the CEνNS prediction of the Standard Model could indicate the existence of new neutrino interactions, which in principle could also be associated with an existing dark sector. For example, a light vector boson may imply corrections to the Weinberg angle, so increasing the precision of this observable will help to probe additional U(1) extensions of the Standard Model. In this talk, we discuss the potential of future germanium-based reactor experiments for precision measurements of the weak mixing angle as well as for the search for a new light vector boson that may exist. Using a data-based reactor antineutrino prediction, we present the experimental sensitivity to the weak mixing angle and the parameters of generic light vector models. In addition, we highlight the impact of characteristic experimental parameters such as detector mass and energy threshold on the expected signal rate. In this way, we show where improvements in future experiment design could have the strongest impact on physics investigations.

Authors: Prof. LINDNER, Manfred (Max-Planck-Institut für Kernphysik); RINK, Thomas (Max--Planck-Institut für Kernphysik); SEN, Manibrata (Max-Planck-Institut für Kernphysik)

Presenter: RINK, Thomas (Max-Planck-Institut für Kernphysik)

Contribution ID: **8** Type: **not specified**

Updated constraints from cosmic-ray upscattering of GeV-scale dark matter

Wednesday, September 20, 2023 9:30 AM (30 minutes)

Dark matter particles with sub-GeV masses can be notoriously difficult to probe, because their typical momenta are insufficient to induce nuclear recoils above the thresholds of conventional direct detection experiments. In fact, it has repeatedly been claimed that even very strongly interacting dark matter could hide in this mass range, supposedly evading all observational bounds. In this talk I present updated constraints resulting from an irreducible component of relativistic halo dark matter, due to cosmic rays continuously upscattering initially non-relativistic dark matter particles. I will demonstrate the importance of accurately modelling the momentum-transfer dependence of the scattering cross section in deriving such constraints, as well as the impact of inelastic scattering events of dark matter particles on their way through atmosphere and soil to the detector location. With all these effects taken properly into account, it turns out that the effect of cosmic-ray upscattering robustly closes a significant part of otherwise unconstrained parameter space for dark matter at the GeV scale.

Author: BRINGMANN, Torsten (University of Oslo)

Presenter: BRINGMANN, Torsten (University of Oslo)

Contribution ID: **9** Type: **not specified**

Inelastic Dark Matter Through The Ages

Tuesday, September 19, 2023 10:00 AM (30 minutes)

The microphysics of Dark Matter (DM) remains an open question in high energy physics and cosmology. Given the diversity of particles in the Standard Model (SM), it is plausible that DM is also composed of more than one type of particle organized in a "dark sector". In case of inelastic or pseudo-Dirac DM, the dark sector consists of two nearly mass-degenerate states. These can participate in exothermic or endothermic reactions, and hence result in novel signatures at cosmological, astrophysical and terrestrial scales.

In this talk, I will use a minimal inelastic DM model to explore its possible (non)-thermal histories and how they map on to observables. In particular, I will investigate the imprints that such a dark sector leaves throughout the history of the universe —in the abundance of light elements, in the cosmic microwave background and in small scale structure—as well as discuss the complementarity between these and terrestrial experiments.

Author: HEEBA, Saniya (McGill University)

Presenter: HEEBA, Saniya (McGill University)

Contribution ID: **10** Type: **not specified**

BSM searches at protoDUNE using the SPS accelerator

Wednesday, September 20, 2023 3:00 PM (30 minutes)

The exquisite capabilities of liquid Argon Time Projection Chambers make them ideal to search for weakly interacting particles in Beyond the Standard Model scenarios. Given their location at CERN the ProtoDUNE detectors may be exposed to a flux of such particles, produced in the collisions of 400 GeV protons (extracted from the Super Proton Synchrotron accelerator) on a target. Here we point out the interesting possibilities that such a setup offers to search for both long-lived unstable particles (Heavy Neutral Leptons, axion-like particles, etc) and stable particles (e.g. light dark matter, or millicharged particles). Our results show that, under conservative assumptions regarding the expected luminosity, this setup has the potential to improve over present bounds for some of the scenarios considered. This could be done within a short timescale, using facilities that are already in place at CERN, and without interfering with the experimental program in the North Area.

Author: COLOMA, Pilar (Instituto de Fisica Teorica UAM-CSIC)

Presenter: COLOMA, Pilar (Instituto de Fisica Teorica UAM-CSIC)

Contribution ID: **11** Type: **not specified**

Opening up the Light Dark Matter Model Space with Scalar Co-SIMPs

In this talk, we present UV completions of the recently proposed number-changing Co-SIMP freeze-out mechanism. In contrast to the standard cannibalistic-type dark matter picture that occurs entirely in the dark sector, the $3 \to 2$ process setting the relic abundance in this case requires one Standard Model particle in the initial and final states. This prevents the dark sector from overheating and leads to rich experimental signatures. We generate the Co-SIMP interaction with a dark sector consisting of two scalars, with the mediator coupling to either nucleons or electrons. In either case, the dark matter candidate is naturally light: nucleophilic interactions favor the sub-GeV mass range and leptophilic interactions favor the sub-MeV mass range. Viable thermal models in these lighter mass regimes are particularly intriguing to study at this time as new developments in low-threshold detector technologies will begin probing this region of parameter space. While particles in the sub-MeV regime can potentially impact light element formation and CMB decoupling, we show that a late-time phase transition opens up large fractions of parameter space. These thermal light dark matter models can instead be tested with dedicated experiments. We discuss the viable parameter space in each scenario in light of the current sensitivity of various experimental probes and projected future reach.

Author: PARIKH, Aditya (Stony Brook University)

Presenter: PARIKH, Aditya (Stony Brook University)

Contribution ID: **12** Type: **not specified**

Looking Forward to New Physics at the LHC: FASER and the FPF

Wednesday, September 20, 2023 2:30 PM (30 minutes)

FASER is a new experiment for Run-3 of the LHC. Situated in the very forward direction 500m from the ATLAS collision point, the experiment is designed to search for light, weakly coupled new particles and to study high energy neutrinos of all flavours. FASER's first physics results will be presented, along with the future prospects of the experiment.
Studies of the physics potential of FASER have highlighted the exciting and broad physics programme in the very forward region of the LHC collisions, and have motivated the proposed Forward Physics Facility (FPF). This would be a new dedicated facility to house several new experiments for the HL-LHC era. The physics potential of the FPF, and the status of technical studies on the facility and proposed experiments will be presented.

Author: BOYD, Jamie (CERN)

Presenter: BOYD, Jamie (CERN)

Contribution ID: **13** Type: **not specified**

Sensitivities to feebly interacting particles: public and unified calculations

Wednesday, September 20, 2023 5:30 PM (20 minutes)

The idea that new physics could take the form of feebly interacting particles (FIPs) - particles with a mass below the electroweak scale, but which may have evaded detection due to their tiny couplings or very long lifetime - has gained a lot of traction in the last decade. Numerous experiments have been proposed to search for such particles. It is important, and now very timely, to consistently compare the potential of these experiments for exploring the parameter space of various well-motivated FIPs. In this talk, I will address this pressing issue by presenting an open-source tool to estimate the sensitivity of many experiments - located at Fermilab or at the CERN's SPS, LHC, and FCC-hh - to various models of FIPs in a unified way: the Mathematica-based code SensCalc.

Authors: Dr OVCHYNNIKOV, Maksym (KIT); Dr TASTET, Jean-Loup (UAM/CSIC); Dr BONDARENKO, Kyrylo (SISSA); Mr MIKULENKO, Oleksii (Leiden University)

Presenter: Dr OVCHYNNIKOV, Maksym (KIT)

Contribution ID: **14** Type: **not specified**

Muon $(g-2)$ and Thermal WIMP DM in $U(1)_{L_\mu - L_\tau}$ Models

$U(1)_{L_\mu - L_\tau} \equiv U(1)_X$ model is anomaly free within the Standard Model (SM) fermion content, and can accommodate the muon $(g-2)$ data for $M_Z \sim O(10-100)$ MeV and $g_X \sim (4-8) \times 10^{-4}$. WIMP type thermal dark matter (DM) can be also introduced for $M_Z \sim 2M_{\rm DM}$, if DM pair annihilations into the SM particles occur only through the s-channel Z exchange. In this work, we show that this tight correlation between M_Z and $M_{\rm DM}$ can be completely evaded both for scalar and fermion DM, if we include the contributions from dark Higgs boson (H_1). Dark Higgs boson plays a crucial role in DM phenomenology, not only for generation of dark photon mass, but also opening new channels for DM pair annihilations into the final states involving dark Higgs boson, such as dark Higgs pair as well as $Z\ Z$ through dark Higgs exchange in the s-channel, and co-annihilation into $Z\ H_1$ in case of inelastic DM. Thus dark Higgs boson will dissect the strong correlation $M_Z \ 2M_{\rm DM}$, and much wider mass range is allowed for $U(1)_X$-charged complex scalar and Dirac fermion DM, still explaining the muon $(g-2)$. We consider both generic $U(1)_X$ breaking as well as $U(1)_X \to Z_2$ (and also into Z_3 only for scalar DM case).

Author: KO, Pyungwon (KIAS)

Co-authors: BAEK, Seungwon (Korea University); KIM, Jongkuk (KIAS)

Presenter: KO, Pyungwon (KIAS)

Contribution ID: **15** Type: **not specified**

Confronting Dark Matter with Dirac Neutrinos

Thursday, September 21, 2023 11:50 AM (10 minutes)

The identity of neutrinos, Dirac or Majorara, is an essential yet unsolved puzzle of nature. By assuming that neutrinos are Dirac particles, we propose a light Dirac neutrino portal dark matter scenario which is based on the possible correlation between the relic right-handed neutrinos and present dark matter abundance. We studied the connection between dark matter and the light right-handed neutrinos produced both thermally and non-thermally and showed that the observables like $\Delta N_{\rm eff}$ and free-streaming length of dark matter can put tight constraints on the available parameter space. For example, in the case of non-thermal dark matter, such constraints can rule out DM mass all the way up to $\mathcal{O}(100$ keV). This can be a possible way to probe the dark matter parameter space even when the direct detection cross-section is suppressed or forbidden in the theory.

Author: Dr NANDA, Dibyendu (Korea Institute for Advanced Study)

Presenter: Dr NANDA, Dibyendu (Korea Institute for Advanced Study)

Contribution ID: **16** Type: **not specified**

Probing Dark Matter-Proton Interactions with Cosmic Reservoirs

Thursday, September 21, 2023 12:00 PM (20 minutes)

Dark Matter (DM) existence is a milestone of the cosmological standard model and, yet, its discovery still remains a complete conundrum. In this talk, I will investigate a unique and original way to probe properties of light dark matter candidates, exploiting the nature of the cosmic-ray (CR) transport inside starburst nuclei (SBNs). Indeed, SBNs are considered CR reservoirs, trapping them for $\sim 10^5$ years up to about PeVs energies, leading to copious production of gamma-rays and neutrinos. As a result, interactions between DM and protons might indelibly change CR transport in these galaxies, perturbing the gamma-rays and neutrino production. I will show that current gamma-ray observations pose strict limits on the elastic cross section down to $\sigma_{\chi p} \simeq 10^{-34}\,\mathrm{cm}^{-}2$ for DM masses $m_\chi \leq 10^{-3}\,\mathrm{MeV}$ and that they have considerable room for improvement with the future gamma-ray measurements in the 0.1-10 TeV range from the Cherenkov Telescope Array.

Author: CHIANESE, Marco (University of Naples Federico II)

Presenter: CHIANESE, Marco (University of Naples Federico II)

Contribution ID: **17** Type: **not specified**

Neutrino non-standard self-interactions and their impact on sterile neutrino dark matter

Thursday, September 21, 2023 11:00 AM (20 minutes)

Sterile neutrinos with keV-scale masses are popular candidates for warm dark matter. In the most straightforward case, they are produced via oscillations with active neutrinos. We focus on mixing with electron neutrinos and antineutrinos, which is object of test in several upcoming or running experiments like TRISTAN, ECHo, and HUNTER. We introduce effective self-interactions of active neutrinos and investigate the effect on the parameter space of sterile neutrino mass and mixing. We demonstrate that depending on the size of the self-interaction, the available parameter space moves closer to, or further away from, the region testable by the mentioned future experiments. In particular, we show that phase 3 of the HUNTER experiment would test a larger amount of parameter space in the presence of self-interactions than without them. We also investigate the effect of the self-interactions on the free-streaming length of the sterile neutrino dark matter, which is important for structure formation observables.

Author: Dr BENSO, Cristina (Max-Planck-Institut für Kernphysik)

Presenter: Dr BENSO, Cristina (Max-Planck-Institut für Kernphysik)

Contribution ID: **18** Type: **not specified**

Asymmetries in Extended Dark Sectors

Thursday, September 21, 2023 5:20 PM (10 minutes)

The observed dark matter relic abundance may be explained by different mechanisms, such as thermal freeze-out/freeze-in, with one or more symmetric/asymmetric components. In this work we investigate the role played by asymmetries in determining the yield and nature of dark matter in non-minimal scenarios with more than one dark matter particle. In particular, we show that the energy density of a particle may come from an asymmetry, even if the particle is asymptotically symmetric by nature. To illustrate the different effects of asymmetries, we adopt a model with two dark matter components. We embed it in a multi-component cogenesis scenario that is also able to reproduce neutrino masses and the baryon asymmetry. In some cases, the model predicts an interesting monochromatic neutrino line that may be searched for at neutrino telescopes.

Author: VATSYAYAN, Drona (IFIC, Universitat de Valencia)

Co-authors: Dr HERRERO-GARCÍA, Juan (IFIC, Universitat de Valencia); Dr LANDINI, Giacomo (IFIC, Universitat de Valencia)

Presenter: VATSYAYAN, Drona (IFIC, Universitat de Valencia)

Contribution ID: **19** Type: **not specified**

Recurrent Axinovae and their Cosmological Constraints

Tuesday, September 19, 2023 4:50 PM (10 minutes)

Axion-like dark matter whose symmetry breaking occurs after the end of inflation predicts enhanced primordial density fluctuations at small scales. This leads to dense axion minihalos (or miniclusters) forming early in the history of the Universe.
Condensation of axions in the minihalos leads to the formation and subsequent growth of axion stars at the cores of these halos. If, like the QCD axion, the axion-like particle has attractive self-interactions there is a maximal mass for these stars, above which the star rapidly shrinks and converts an $\mathcal{O}(1)$ fraction of its mass into unbound relativistic axions. This process would leave a similar (although in principle distinct) signature in cosmological observables as a decaying dark matter fraction, and thus is strongly constrained. We place new limits on the properties of axion-like particles that are independent of their non-gravitational couplings to the standard model.

Authors: XIAO, Huangyu (Fermilab); Prof. WEINER, Neal; FOX, Patrick J.

Presenter: XIAO, Huangyu (Fermilab)

Contribution ID: **20** Type: **not specified**

The Light Dark Matter eXperiment (LDMX)

Wednesday, September 20, 2023 4:30 PM (20 minutes)

The constituents of dark matter are still unknown, and the viable possibilities span a very large mass range. Specific scenarios for the origin of dark matter sharpen the focus on a narrower range of masses: the natural scenario where dark matter originates from thermal contact with familiar matter in the early Universe requires the DM mass to lie within about an MeV to 100 TeV. Considerable experimental attention has been given to exploring Weakly Interacting Massive Particles in the upper end of this range (few GeV –~TeV), while the region ~MeV to ~GeV is largely unexplored. Most of the stable constituents of known matter have masses in this lower range, tantalizing hints for physics beyond the Standard Model have been found here, and a thermal origin for dark matter works in a simple and predictive manner in this mass range as well. It is therefore a priority to explore. If there is an interaction between light DM and ordinary matter, as there must be in the case of a thermal origin, then there necessarily is a production mechanism in accelerator-based experiments. The most sensitive way, (if the interaction is not electron-phobic) to search for this production is to use a primary electron beam to produce DM in fixed-target collisions. The Light Dark Matter eXperiment (LDMX) is a planned electron-beam fixed-target missing-momentum experiment that has unique sensitivity to light DM in the sub-GeV range. This contribution will give an overview of the theoretical motivation, the main experimental challenges and how they are addressed, as well as projected sensitivities in comparison to other experiments.

Presenter: MANS, Jeremiah (University of Minnesota)

Contribution ID: **21** Type: **not specified**

Early galaxy formation and its large-scale effects in the JWST era

Thursday, September 21, 2023 2:00 PM (30 minutes)

Galaxy formation in the first billion years mark a time of great upheaval in our cosmic history: the first sources of light in the Universe, these galaxies ended the 'cosmic dark ages' and produced the first photons that could break apart the hydrogen atoms suffusing all of space starting the process of cosmic reionization. At the forefront of astronomical research, the past few years have seen cutting-edge instruments such as JWST and ALMA provide tantalising glimpses of such galaxies chaotically assembling in an infant Universe. I will show how this data has provided an unprecedented opportunity to pin down the reionization state of the Universe, understand the physical properties of early galaxies, shed light on their dusty nature and study the key physics driving their formation and evolution. I will try to give a flavour of how galaxies can in the first billion years can also provide a powerful testbed for Dark Matter models beyond "Cold Dark Matter".

Author: Dr DAYAL, Pratika (Kapteyn Astronomical Institute)

Presenter: Dr DAYAL, Pratika (Kapteyn Astronomical Institute)

Contribution ID: **22** Type: **not specified**

Gauged quintessence

Thursday, September 21, 2023 5:00 PM (20 minutes)

Dark energy is the least understood component of the universe despite its dominance. A proper understanding of the universe might require an investigation of the possible symmetries of the dark sector. We introduce a gauge symmetry to a quintessence dark energy field and discuss its implications. This talk is based on 2208.09229 and 2306.01291.

Author: LEE, Hye-Sung (KAIST)

Presenter: LEE, Hye-Sung (KAIST)

Contribution ID: **23** Type: **not specified**

Probing for light new particles with the LUXE experiment

Wednesday, September 20, 2023 5:00 PM (20 minutes)

The proposed LUXE experiment (LASER Und XFEL Experiment) at DESY, Hamburg, using the electron beam from the European XFEL, aims to probe QED in the non-perturbative regime created in collisions between high-intensity laser pulses and high-energy electron or photon beams. This setup also provides a unique opportunity to probe physics beyond the standard model. In this talk we show that by leveraging the large photon flux generated at LUXE, one can probe axion-like-particles (ALPs) up to a mass of 350 MeV and with photon coupling of 3×10−6 GeV−1. This reach is comparable to the background-free projection from NA62. In addition, we will discuss the ongoing optimisation of the experimental setup for the ALP search.

Author: LIST, Jenny (DESY)

Presenter: QUISHPE, Raquel (Karlsruhe Institute of Technology)

Contribution ID: **24** Type: **not specified**

X-rays constraints on sub-GeV Dark Matter

Wednesday, September 20, 2023 11:20 AM (10 minutes)

In this talk, I will present updated constraints on 'light' dark matter (DM) particles with masses between 1 MeV and 5 GeV. In this range, we can expect DM-produced $e^{\pm}$ pairs to upscatter ambient photons in the Milky Way via Inverse Compton, and produce a flux of X-rays that can be probed by a range of space observatories. Using diffuse X-ray data from XMM-Newton, INTEGRAL, NuSTAR and Suzaku, we compute the strongest constraints to date on annihilating DM for 200 MeV < $m_{\rm DM}$ < 5 GeV and decaying DM for 100 MeV < $m_{\rm DM}$ < 5 GeV. I will also discuss possible future developments of these results and this technique.

Author: KOECHLER, Jordan (LPTHE - Sorbonne Université)

Presenter: KOECHLER, Jordan (LPTHE - Sorbonne Université)

Contribution ID: **25** Type: **not specified**

Looking forward to photon-coupled sub-GeV long-lived particles

Wednesday, September 20, 2023 5:20 PM (10 minutes)

Many Dark Sector models contain photon-coupled long-lived particles. An outstanding example is an axion-like particle decaying into two photons. The forward physics detectors at the LHC, e.g., FASER, were shown to be particularly suitable for hunting ~sub-GeV ALPs thanks to numerous photons produced in pp collisions, which in turn are efficiently converted into ALPs by the Primakoff scattering. We consider a few of beyond the SM physics scenarios in which similar processes can occur, in particular *massive spin-2 portal and inelastic DM with EM form factors.* We find that FASER2 and SHiP experiments will cover a significant part of the available parameter space for each of them. Moreover, we show that secondary production of LLPs at FASER2 can improve the coverage of parameter spaces in the regime of smaller lifetimes.

Author: JODLOWSKI, Krzysztof (IBS-CTPU)

Presenter: JODLOWSKI, Krzysztof (IBS-CTPU)

Contribution ID: **26** Type: **not specified**

Forbidden dark matter annihilation into leptons with full collision terms

Thursday, September 21, 2023 5:30 PM (10 minutes)

The standard approach of calculating the relic density of thermally produced dark matter based on the assumption of kinetic equilibrium is known to fail for forbidden dark matter models since only the high momentum tail of the dark matter phase space distribution function contributes significantly to dark matter annihilations. Furthermore, it is known that the computationally less expensive Fokker-Planck approximation for the collision term describing elastic scattering processes between non-relativistic dark matter particles and the Standard Model thermal bath breaks down if both scattering partners are close in mass. This, however, is the defining feature of the forbidden dark matter paradigm. We therefore present the effect of the full elastic collision term on the relic density for a simplified model featuring forbidden dark matter annihilations into muon or tau leptons through a scalar mediator. The overall phenomenological outcome is that the updated relic density calculation results in a significant reduction of the experimentally allowed parameter space compared to the traditional approach, which solves only for the abundance. In addition, almost the entire currently viable parameter space can be probed with CMB-S4, next-generation beam-dump experiments or at a future high-luminosity electron-position collider, except for the resonant region where the mediator corresponds to approximately twice the muon or tau mass.

Author: Mr WIGGERING, Luca (University of Münster)

Co-authors: Dr ABOUBRAHIM, Amin (University of Münster); Prof. KLASEN, Michael (University of Münster)

Presenter: Mr WIGGERING, Luca (University of Münster)

Contribution ID: **27** Type: **not specified**

SIMPly add a dark photon

Tuesday, September 19, 2023 11:20 AM (10 minutes)

Observations of Dark Matter (DM) density profiles are in tension with the standard collisionless DM paradigm and can hint at DM self-interactions. Moreover, observations over different scales require the self-interactions to be velocity-dependent. In the talk I will present a dark sector consisting of dark pions and dark photons that can yield the required velocity dependence, via resonant exchange of a dark photon. The pions can be strongly interacting massive particle (SIMP) dark matter, produced by the freeze-out of 3 to 2 interactions, with naturally large self-interactions and masses $m_\pi \sim \mathcal{O}(100)$ MeV. I will then discuss the phenomenology as a result of the resonance, as well as show the viable regions of parameter space.

Author: BRAAT, Pieter (Nikhef)

Co-author: Prof. POSTMA, Marieke (Nikhef, Radboud University)

Presenter: BRAAT, Pieter (Nikhef)

Contribution ID: **28** Type: **not specified**

How to Measure the Spin of Dark Matter in $e^+e^- \to \gamma + X$

Wednesday, September 20, 2023 12:20 PM (10 minutes)

Dark Matter has eluded us for decades and continues to do so. Currently lepton colliders provide exclusion limits on individual dark matter models, but many models may have either identical or indistinguishable signals. Hence there is a need for new methods or observables to determine the nature of the dark matter, especially if more than one candidate is present. Using e^+e^- processes with a mono-photon signal and missing energy, we look into whether the helicities of the incoming beams and the outgoing photon can be used to differentiate between two dark matter models: Dark Photons and Axion-Like-Particles (ALPs). Due to the dark particles' spin and coupling structures, the two models have differing contributions and dependencies on the incoming fermions' spin. Focusing on Belle II and looking at a dark matter mass range of [0.1, 9.75] GeV, we show how the helicities of the incoming beams, together with angular distributions, can be used to discriminate between the dark photon and ALP dark matter.

Authors: ERNER, Sofie (Durham University); Dr BAUER, Martin (Durham University)

Presenter: ERNER, Sofie (Durham University)

Contribution ID: **29** Type: **not specified**

Using axion mini-clusters to disentangle the axion-photon coupling and the dark matter density

Tuesday, September 19, 2023 4:30 PM (20 minutes)

Dark matter direct (and indirect) detection experiments usually can only determine a specific combination of a power of the coupling and the dark matter density. This is also true for axion haloscopes which are sensitive to the product g^2ρ, the combination of axion-photon coupling squared and the dark matter density. We show, that in the lucky case when we intersect with a so-called minicluster of a suitable size, we can utilize the spectral information available in haloscopes to determine the gravitational potential of the mini-cluster. We can the use this to separately measure coupling and density of the mini-cluster.

Authors: Prof. JAECKEL, Joerg; MONTOYA, Valentina; DANDOY, Virgile (Karlsruhe Institute for Technology)

Presenter: DANDOY, Virgile (Karlsruhe Institute for Technology)

Contribution ID: **30** Type: **not specified**

DELIGHT and FOREHUNT : dedicated detectors at FCC-hh for light long-lived particles

Wednesday, September 20, 2023 5:50 PM (10 minutes)

Our efforts in searching for hints of new physics require close attention to the signatures of light particles arising in theories beyond the Standard Model (BSM) physics, as they could have eluded our searches. In many theories, these light BSM particles can have long lifetimes and are worth exploring. We focus on light long-lived particles (LLPs) coming from the decay of the discovered Higgs boson and B-mesons. We propose dedicated and optimised LLP detectors for the future circular hadronic collider (FCC-hh) and study their sensitivity.

Authors: Prof. BHATTACHERJEE, Biplob (Centre for High Energy Physics, Indian Institute of Science, Bengaluru 560012, India); Prof. DREINER, Herbi K. (BCTP and Physikalisches Institut der Universit¨at Bonn, Nußallee 12, 53115 Bonn, Germany); Dr GHOSH, Nivedita (Centre for High Energy Physics, Indian Institute of Science, Bengaluru 560012, India); Prof. MATSUMOTO, Shigeki (Kavli IPMU (WPI), UTIAS, University of Tokyo, Kashiwa, Chiba, 277-8583, Japan); SENGUPTA, Rhitaja (BCTP and Physikalisches Institut der Universität Bonn, Germany); Mr SOLANKI, Prabhat (Centre for High Energy Physics, Indian Institute of Science, Bengaluru 560012, India)

Presenter: SENGUPTA, Rhitaja (BCTP and Physikalisches Institut der Universität Bonn, Germany)

Contribution ID: **31** Type: **not specified**

Light Dark Matter Search with Dual-Phase Argon Time Projection Chamber

Wednesday, September 20, 2023 12:00 PM (20 minutes)

The DarkSide experiment is a direct dark matter search using dual-phase argon time projection chamber. Its preceding experiment, DarkSide-50, produced world-class result for light dark matter search based on a low-threshold electron-counting measurement. A new proposed detector, DarkSide-LowMass, is optimized for such measurement based on the success of the DarkSide-50 and progress towards the DarkSide-20k. The sensitivity is explored for various potential energy thresholds and background rates. Our studies show that DarkSide-LowMass can achieve sensitivity to light dark matter down to the level of the solar neutrino fog for GeV-scale masses and significant sensitivity down to 10 MeV/c², taking into account the Migdal effect or interactions with electrons. Requirements for optimizing the detector's sensitivity are explored, as well as potential gains from modeling and mitigating spurious electron backgrounds that may dominate the signal at the lowest energies.
In this talk, we present the overview of the DarkSide-LowMass, followed by the recent results from the DarkSide-50.

Author: KIMURA, Masato (AstroCeNT, CAMK/PAN)

Presenter: KIMURA, Masato (AstroCeNT, CAMK/PAN)

Contribution ID: **32** Type: **not specified**

Bounds on Axions From Obscured Magnetars

Tuesday, September 19, 2023 5:20 PM (10 minutes)

Coupling of axions or axion-like particles (ALPs) with photons may lead to photons escaping optically opaque regions by oscillating into ALPs. This phenomenon can be probed through the Light Shining through Wall (LSW) technique. While this LSW technique has been used previously in controlled laboratory settings to constrain the ALP-photon coupling ($g_{a\gamma}$), we show that this can also be applied in astrophysical environments. We find that obscured magnetars in particular are excellent candidates for this purpose. A fraction of photons emitted by the magnetar may convert to ALPs in the magnetar neighborhood, escape the large hydrogen column densities, and convert back into photons due to the interstellar magnetic field. Using limits on the observed flux, we can constrain the contribution of this process, and hence constrain $g_{a\gamma}$. The effects of resonant conversion near the magnetar as well as ALP-photon oscillations in the interstellar medium are carefully considered. We find that this can constrain $g_{a\gamma} \leq 10^{-10}$ GeV^{-1} for low mass axions ($m_a < 10^{-12}$ eV) with suitable choices of magnetar candidates. The study clearly demonstrates the potential for employing the LSW technique for obscured magnetars for probing and constraining ALP-photon couplings.

Authors: Mr CHATTOPADHYAY, Dibya S. (Tata Institute of Fundamental Research, Mumbai); Prof. DASGUPTA, Basudeb (Tata Institute of Fundamental Research, Mumbai); Prof. DIGHE, Amol (Tata Institute of Fundamental Research, Mumbai); Dr NARANG, Mayank (Academia Sinica Institute of Astronomy & Astrophysics)

Presenter: Mr CHATTOPADHYAY, Dibya S. (Tata Institute of Fundamental Research, Mumbai)

Contribution ID: **33** Type: **not specified**

Thermal friction as a solution to the Hubble tension

Thursday, September 21, 2023 2:30 PM (30 minutes)

I will talk about the two most prominent tensions of the LCDM model of cosmology, the Hubble Tension and the Large-Scale Structure (LSS) Tension. Both emerge between early and late universe data sets, yet no new single new physics explanation is able to address both successfully. An epoch of Early Dark Energy is a promising hypothesis that can resolve the Hubble tension but has been shown to exacerbate the LSS tension. I will discuss my work on thermal friction acting upon the early dark energy field, where extra radiation is a built-in feature of the model. The extra-radiation holds promise to ease the LSS tension alongside the Hubble tension. Additionally, thermal friction by design eliminates fine-tuning present in the original proposal. I'll discuss and motivate the model and will show results for it in light cosmic microwave background (CMB), baryon acoustic oscillation and supernova data, including the SH0ES H0 measurement and the Dark Energy Survey Y1 data release.

Author: BERGHAUS, Kim (Stony Brook University)

Presenter: BERGHAUS, Kim (Stony Brook University)

Contribution ID: **34** Type: **not specified**

Light Dark ALPs

Tuesday, September 19, 2023 9:30 AM (30 minutes)

Axion-like particles –ALPs –are predicted in many extensions of the Standard Model with a spontaneously broken symmetry. If ALPs exist in Nature, they leave interesting signatures at colliders and other experiments. In this talk, you will hear about new ideas to search for axion-like particles with GeV-scale masses. I will explain what we learn from these searches about ALP interactions with particles of the Standard Model.

Author: WESTHOFF, Susanne (Radboud University / Nikhef)

Presenter: WESTHOFF, Susanne (Radboud University / Nikhef)

Contribution ID: **35** Type: **not specified**

Beyond the Standard Model physics searches with double-beta decays

Thursday, September 21, 2023 9:30 AM (30 minutes)

Nuclear double-beta decays are a unique probe to search for new physics Beyond the Standard Model. Still-unknown particles, non-standard interactions, or the violation of fundamental symmetries would affect the decay kinematic, creating detectable and characteristic experimental signatures. In particular, the energy distribution of the electrons emitted in the decay gives an insight into the decay mechanism and has been studied in several isotopes and experiments. No deviations from the prediction of the Standard Model have been reported yet. However, several new experiments are underway or in preparation and will soon increase their sensitivity, exploring uncharted parts of the parameter space. This talk will cover phenomenological and experimental aspects related to new-physics searches in double-beta decay experiments, focusing on the testable models, the most-sensitive detection techniques, and the discovery opportunities of this field.

Author: BOSSIO, Elisabetta (TUM)

Presenter: BOSSIO, Elisabetta (TUM)

Contribution ID: **36** Type: **not specified**

Probing dark matter microphysics with gravitational waves and 21cm emission

Thursday, September 21, 2023 4:50 PM (10 minutes)

The microphysics of dark matter remains a mystery, with current data only setting upper bounds on interaction cross sections, or lower bounds on the mass in the case of a thermal relic. Going to higher redshift and smaller scales will let us improve these bounds, but more importantly, may allow us to distinguish between models with otherwise similar signals. In particular, I will present a novel method for constraining models with suppressed small scale structure using gravitational waves, along with forecasts for complementary constraints from 21cm intensity mapping. The latter is especially important regarding what is necessary to distinguish interacting dark matter from warm dark matter.

Author: MOSBECH, Markus (RWTH Aachen)

Presenter: MOSBECH, Markus (RWTH Aachen)

Contribution ID: **37** Type: **not specified**

Heavy Photon Search at Jefferson Lab

Wednesday, September 20, 2023 4:50 PM (10 minutes)

A popular model for light (sub-GeV) Dark Matter (DM) is that its constituents belong to a Hidden Sector, uncharged under the Standard Model (SM) forces, and coupled to the SM through a new force carrier. In particular, theoretically well-motivated models propose the existence of a new U(1) light gauge boson, called the heavy (or dark) photon A'which kinetically mixes with the SM photon. The Heavy Photon Search (HPS) at the Thomas Jefferson National Accelerator Facility (JLAB, USA) has been primarily designed to search for electro-produced heavy photons decaying into electron-positron pairs. In HPS, experimental signatures of heavy photon decays are either the detection of displayed decay vertices or a resonant peak in the electron-positron invariant mass spectrum, depending on the heavy photon mass and the coupling strength. In this presentation, I will describe the design and performance of the HPS detector before presenting the results of the analysis of data collected during the 2016 engineering run. Additionally, I will talk about the status of the ongoing analysis of two additional, larger datasets from 2019 and 2021.

Author: GAISER, Sarah (SLAC/Stanford)

Presenter: GAISER, Sarah (SLAC/Stanford)

Contribution ID: **38** Type: **not specified**

Waves in a Box: Resonant Cavities for Axion and GW Detection

Tuesday, September 19, 2023 2:30 PM (30 minutes)

I will discuss electromagnetic signals generated by gravitational waves (GWs) and light axion dark matter in microwave cavity experiments. In our proposed setup we generate and detect a heterodyne signal. This idea has the potential to cover a factor of 100 in mass on the QCD line and an extra 15 orders of magnitude of unexplored ALPs parameter space. Two prototypes are currently being designed at SLAC and at Fermilab. The same logic can be applied to gravitational waves giving potentially one of the best detectors at high frequencies (MHz to GHz). I will also show that, contrary to the standard lore, existing axion dark matter cavity experiments are already sensitive to high-frequency GWs with strains as small as h ~ 10^{-22} – 10^{-21}.

Author: D'AGNOLO, Raffaele Tito (CEA IPhT Saclay)

Presenter: D'AGNOLO, Raffaele Tito (CEA IPhT Saclay)

Contribution ID: **39** Type: **not specified**

Mineral Detectors for Neutrinos and Dark Matter

Thursday, September 21, 2023 9:00 AM (30 minutes)

Minerals have been used as nuclear track detectors for more than 50 years - nuclear recoils leave latent damage in the crystal structure. In the past years, there has been much interest in fundamental physics applications for such detectors, not least because of advances in microscopy techniques that have revolutionized our abilities to image defects at the nm scale. In this talk, I will discuss a range of proposed applications of mineral detectors, in particular "paleo-detector" searches for Dark Matter and astrophysical neutrinos: Leveraging the 100 Myr - 1 Gyr exposure times natural minerals on Earth provide, one could not only measure such sources of nuclear recoils with unprecedented exposure, but also learn about their properties, for example, the distribution of Dark Matter in our Galaxy, the evolution of our Sun, or the star formation history of the Milky Way. Research groups in America, Asia, and Europe are pursuing feasibility studies of mineral detectors for neutrinos and Dark Matter, and I will also briefly report on the status and plans of these studies.

Author: BAUM, Sebastian

Presenter: BAUM, Sebastian

Contribution ID: **40** Type: **not specified**

Novel limits on solar reflected dark matter with XENONnT

Wednesday, September 20, 2023 11:50 AM (10 minutes)

The XENONnT experiment is a low-background dual phase liquid xenon Time Projection Chamber (TPC) with 5.9 tonnes of instrumented liquid xenon. Improved liquid xenon purification and radon distillation system along with various background mitigation strategies brought the electronic recoil backgrounds down to an unprecedented low of (15.8 ± 1.3) events/(keV ·t ·y) below recoil energies of 30 keV. Low-energy electronic recoil data corresponding to an exposure of 1.16 tonne-years is used to search for a signal of sub-GeV dark matter boosted by reflection off the sun. We observe no excess in the (1, 140) keV search region and report novel stringent upper limits on the dark matter-electron scattering cross section in the dark matter mass range between 10 keV and 9 MeV.

Authors: TAN, Pueh Leng (Stockholm University); Dr EMKEN, Timon; Prof. CONRAD, Jan (Stockholm University)

Presenter: TAN, Pueh Leng (Stockholm University)

Contribution ID: **41** Type: **not specified**

No Need for Speed: Halo-Independent Analysis of Dark-Matter-Electron Scattering

Wednesday, September 20, 2023 11:30 AM (20 minutes)

DM direct detection experiments and the interpretation of their results are sensitive to the velocity structure of the galactic halo. However, the halo model is subject to large uncertainties. In this talk I will present a formalism to analyze DM-electron scattering events in semiconductor experiments without assuming a particular DM velocity distribution. Using simulated data, I will show that halo-independent information about DM properties can be extracted via numerical fits in which the DM velocity is treated as a collection of nuisance parameters. I will argue that the complementarity of semiconductor materials with different crystal form factors is essential to inferring the DM mass, interaction structure, and velocity distribution. Finally, I will discuss an application of the technique to real data from the SENSEI and EDELWEISS experiments.

Author: BERNREUTHER, Elias (Fermilab)

Co-authors: FOX, Patrick J. (Fermilab); LILLARD, Benjamin (University of Oregon); TAKI, Anna--Maria (University of Oregon); YU, Tien-Tien (University of Oregon)

Presenter: BERNREUTHER, Elias (Fermilab)

Contribution ID: **42** Type: **not specified**

Reconstructing ALP properties from imprecise observations with ML

Tuesday, September 19, 2023 12:00 PM (20 minutes)

Inferring theory parameters starting from observed events is a difficult task in high energy physics. This becomes particularly troublesome when dealing with events whose observables are not precisely measured and we want to understand the inference capability of multiple experimental setups. As a representative scenario, we will consider the production of ALPs and their subsequent decay into photons at beam-dump experiments. This type of signal presents issues due to the difficulty in reconstructing the photon properties, especially their directionality. In addition to this, the design is not finalized, which means that we would like to understand how modifying the detector properties changes our inference power. We construct a set of conditional invertible neural networks for the different experimental setups under scrutiny: by learning the posterior starting from the observed events, we are able to correctly state the model parameters and most importantly the uncertainty on them. The uncertainty on the model parameters can be seen as a measure of the inference power of the experimental setups, thus providing a way to compare them.

Author: Dr MORANDINI, Alessandro (KIT, IAP)

Co-authors: KAHLHOEFER, Felix (KIT); FERBER, Torben (KIT ETP)

Presenter: Dr MORANDINI, Alessandro (KIT, IAP)

Contribution ID: **43** Type: **not specified**

A global analysis of decaying cosmological ALPs

Thursday, September 21, 2023 4:30 PM (20 minutes)

Axion-like particles (ALPs) decaying before the time of recombination can have strong implications in a range of cosmological and astrophysical observations. In this talk I present a global analysis of a model of decaying ALP, focusing specifically on their coupling to photons. Exploiting the multidisciplinary nature of the GAMBIT framework, we combine state-of-the-art calculations of the irreducible ALP freeze-in abundance, primordial element abundances (including photodisintegration through ALP decays), CMB spectral distortions and temperature anisotropies, and astrophysical constraints from supernovae and stellar cooling. Most notable among the interesting results that I will present are a definite lower bound on the ALP mass, and a surprising improvement of the fit to the primordial abundances compared to vanilla ΛCDM.

Author: GONZALO, Tomas (KIT)

Presenter: GONZALO, Tomas (KIT)

Contribution ID: **44** Type: **not specified**

Search for Inelastic Dark Matter with a Dark Higgs at Belle II

Tuesday, September 19, 2023 12:20 PM (10 minutes)

Belle II has a unique reach for a broad class of models that postulate the existence of dark matter particles in the MeV-GeV mass range. One highly motivated scenario is a model which involves inelastic dark matter, consisting of two dark matter states with a mass splitting between them and the presence of a dark Higgs boson. This model has a signature of up to two displaced vertices, one from the resonant decay of the dark Higgs and another non-resonant one emerging from the decay of the involved dark matter particles. This talk will present studies of an ongoing search for such signatures using Belle II simulation, which is not only challenging due to the presence of displaced vertices but also because of the seven-dimensional parameter space of the model.

Authors: ECKER, Patrick (KIT); DE PIETRO, Giacomo; EPPELT, Jonas; FERBER, Torben (KIT ETP); GOLDENZWEIG, Pablo (KIT)

Presenter: ECKER, Patrick (KIT)

Contribution ID: **45** Type: **not specified**

How to catch relic neutrinos?

Thursday, September 21, 2023 11:30 AM (20 minutes)

I will briefly review the old story of relic neutrinos and their potential role in cosmology and in particle physics, the state of the art in experimental searches for them and possible steps forward as I see them

Author: Prof. ALEXEY, Boyarsky (Leiden University)

Presenter: Prof. ALEXEY, Boyarsky (Leiden University)

Contribution ID: **46** Type: **not specified**

ALP wiggles in photon spectra

Tuesday, September 19, 2023 5:50 PM (10 minutes)

Axions and axion-like-particles (ALPs) are characterized by their two-photon coupling, which entails so-called photon-ALP oscillations as photons propagate through a magnetic field. These oscillations lead to distinctive signatures in the energy spectrum of high-energy photons from astrophysical sources, allowing one to probe the existence of ALPs. In particular, photon-ALP oscillations will induce energy dependent oscillatory features, or "ALP wiggles", in the photon spectra. We propose to use the discrete power spectrum to search for ALP wiggles and present a model-independent statistical test. By using PKS 2155-304 as an example, we show that the method has the potential to significantly improve the experimental sensitivities for ALP wiggles. Furthermore, we conduct a simple model-independent search for ALP wiggles in the Fermi sources 3C454.3 and CTA 102.

Authors: TJEMSLAND, Jonas (Norwegian University of Science and Technology); Prof. KACHELRIESS, Michael (NTNU)

Presenter: TJEMSLAND, Jonas (Norwegian University of Science and Technology)

Contribution ID: **47** Type: **not specified**

Model-Independent Searches for sub-MeV Dark Particles via Weak Decay Recoil Spectroscopy

Thursday, September 21, 2023 10:00 AM (30 minutes)

Nuclear beta and electron capture (EC) decay serve as sensitive probes of the structure and symmetries of the charged weak force between quarks and leptons. As such, precision measurements of the final-state products in these processes can be used as powerful laboratories to search for new physics from the meV to TeV scale. Significant advances in rare isotope availability and quality, coupled with decades of sensing technique development from the AMO community have led us into a new era of fundamental tests of nature using unstable nuclei. For the past few years, we have taken the approach of embedding radioisotopes in thin-film superconducting tunnel junctions (STJs) to precisely measure the recoiling atom that gets an eV-scale "kick" from the neutrino following EC decay. Since these recoils are encoded with the fundamental quantum information of the decay process, they can also carry unique signatures of weakly coupled beyond standard model (BSM) physics; including neutrino mass and light-mass "dark"particles created within the Q-value window of the decay. These measurements provide a complimentary and (crucially) model-independent portal to the dark sector with sensitivities that push towards synergy between laboratory and cosmological probes. Ongoing and future work in this field include extending the physics reach of recoil experiments with STJs using "on-line"measurements of short-lived systems as well as using macroscopic amounts of harvested rare isotopes in optically levitated nanospheres for direct momentum measurements of the decay recoils.

Author: LEACH, Kyle (FRIB and Colorado School of Mines)

Presenter: LEACH, Kyle (FRIB and Colorado School of Mines)

Contribution ID: **49** Type: **not specified**

Renormalization group effects in QCD axion phenomenology

Tuesday, September 19, 2023 5:30 PM (20 minutes)

We study the impact of renormalization group effects on QCD axion phenomenology. Focusing on the DFSZ model, we argue that the relevance of running effects for the axion couplings crucially depends on the scale where the heavier Higgs doublet, charged under the Peccei-Quinn symmetry, is integrated out. We study the impact of these effects on astrophysical and cosmological bounds as well as on the sensitivity of helioscopes experiments such as IAXO and XENONnT, showing that they can be sizable even in the most conservative case in which the two Higgs doublets remain as light as the TeV scale. We provide simple analytical expressions that accurately fit the numerical solutions of the renormalization group equations as a function of the mass scale of the heavy scalars.

Author: OKAWA, Shohei (ICCUB, University of Barcelona)

Presenter: OKAWA, Shohei (ICCUB, University of Barcelona)

Contribution ID: **50** Type: **not specified**

A Z portal to the dark sector

Tuesday, September 19, 2023 11:30 AM (20 minutes)

This talk argues that rare Z decays to a QCD-like dark sector provide unexplored opportunities to the LHC experiments. We present two distinct classes of ultraviolet completions of such Z portal, including a novel scenario featuring a light Z'vector boson, which we show to be compatible with electroweak precision data. We then highlight the phenomenological signatures, focusing on the interplay between dark shower signals in Z decays and searches for rare decays of B mesons.

Author: SALVIONI, Ennio (University of Padua)

Presenter: SALVIONI, Ennio (University of Padua)

Contribution ID: **51** Type: **not specified**

Axion-like particle dark matter: Beyond the standard paradigm

Tuesday, September 19, 2023 5:00 PM (20 minutes)

Axions and axion-like particles (ALPs) are among the most popular candidates that explain the origin of the mysterious dark matter. The most popular ALP production mechanism studied in the literature is the misalignment mechanism, where an ALP field with a quadratic or cosine potential has negligible kinetic energy initially, and it starts oscillating when its mass becomes comparable to the Hubble scale. Recently, there has been an interest in models that go beyond the standard assumptions. These models not only extend the ALP dark matter parameter space but also provide a rich phenomenology which is absent in the standard scenario. In particular, the ALP fluctuations grow exponentially via parametric resonance and tachyonic instabilities. In this talk, after giving an overview of the alternative production mechanisms, I will discuss the observational consequences of this exponential growth and show that a sizable region of the ALP parameter space becomes testable even if ALPs have only gravitational interactions.

Author: ERÖNCEL, Cem (Istanbul Technical University)

Presenter: ERÖNCEL, Cem (Istanbul Technical University)

Contribution ID: **52** Type: **not specified**

Dark Pions at Neutrino Facilities

We present a chiral non-abelian dark sector model featuring a spontaneous $SU(3) \times SU(2) \to SU(3)$ symmetry breaking, resulting in the formation of dark mesons and baryons. The absence of a gauged $U(1)$ symmetry allows the dark baryons, typically the dark protons, to potentially serve as dark matter candidates. The model incorporates HNLs and explores scenarios with enhanced active-to-sterile neutrino mixing. We analyze the mixing between the dark meson π_D and the SM mesons π^0 and η. Utilizing this mixing and the known π^0 flux at neutrino facilities, we investigate the decay of π_D into pairs of HNLs. This study presents a novel approach where the ν_D emerges directly from the π^0 decay, providing distinct kinematic distributions compared to conventional neutrino mixing studies. Our investigation includes the DUNE and ICARUS near detectors, as well as stopped pion facilities and FASERν. Additionally, we consider the atmospheric π^0 flux for ν_D production, offering intriguing possibilities for the DUNE far detector.

Authors: Dr ABDULLAHI, Asli (Fermilab); Dr TABRIZI, Zahra (Northwestern University); Prof. DE GOUVÊA, André (Northwestern University); Prof. DUTTA, Bhaskar (Texas A&M University); Dr SHOEMAKER, Ian (Virginia Tech)

Presenter: Dr ABDULLAHI, Asli (Fermilab)

Contribution ID: **53** Type: **not specified**

Results and progress of axion haloscope experiments

Tuesday, September 19, 2023 2:00 PM (30 minutes)

Axions may well solve both, the Dark Matter and the strong CP problems.
If they really comprise the dark matter, there are good prospects to detect them in the near future.
Presently already some experiments based on cavities are taking data with a sensitivity that should lead to an axion dark matter discovery, should their mass be in the “classical invisible axion mass range” around μeV.
Lately, many new experimental approaches have been proposed to also probe complementary, theoretically
very well motivated mass range.
Different haloscope approaches with prospect to being sensitive to dark matter axions will be discussed
and latest results and perspectives of some experiments will be highlighted.

Author: MAJOROVITS, Béla (MPI für Physik)

Presenter: MAJOROVITS, Béla (MPI für Physik)

Contribution ID: **54** Type: **not specified**

Testing dark forces with LSS

Thursday, September 21, 2023 3:30 PM (30 minutes)

If the dark sector interacts with the visible one only through gravitational interactions, precision cosmology might be our best tool to test its dynamics. As a first step in this direction, we investigate the imprints of new long range forces acting solely on dark matter. Accounting for the presence of dark fifth forces in the effective field theory of large scale structure we derive the current best bound from a combination of CMB, BAO and BOSS data and forecast the sensitivity of future galaxy surveys. The presence of relative density and velocity fluctuations induces a pole in the bispectrum of two different tracers signalling the violation of the equivalence principle. We discuss under which circumstances a test of the equivalence principle violation can be performed in future surveys.

Author: REDIGOLO, Diego (INFN Florence)

Presenter: REDIGOLO, Diego (INFN Florence)

Contribution ID: **55** Type: **not specified**

Searching for New Physics with the NANOGrav Pulsar Timing Array

Wednesday, September 20, 2023 2:00 PM (30 minutes)

NANOGrav, the North American Nanohertz Observatory for Gravitational Waves, recently announced compelling evidence for the existence of a stochastic gravitational-wave background at nanohertz frequencies. This signal may either be of astrophysical origin and stem from a population of supermassive black-hole binaries, or of cosmological origin, reaching us from the early Universe. In this talk, I will focus on the latter possibility and illustrate how the NANOGrav data enables us to probe new physics at the pulsar timing array (PTA) frontier. Specifically, I will show how PTA data allows us to study models of physics beyond the Standard Model at extremely high energies, including scenarios of grand unification and string theory, before I then turn to searches for new physics in our Milky Way, including scenarios of ultra-light dark matter and dark-matter substructures. I will conclude by giving a brief outlook on the future of the field, which is sure to see some spectacular progress in the coming years and decades. This talk is based on 2306.16219.

Author: SCHMITZ, Kai (University of Münster)

Presenter: SCHMITZ, Kai (University of Münster)

Contribution ID: **56** Type: **not specified**

Latest results from the NA64 experiment

Wednesday, September 20, 2023 3:30 PM (30 minutes)

NA64 is a fixed target experiment at CERN searching for dark sectors in the scattering of electron, positron and muons on a target. In this talk, we report its latest results on sub-GeV Dark Matter searches with the 2016-2022 statistics (arXiv:2307.02404). With the new data, NA64 is starting to probe for the first time the very interesting region of parameter space motivated by benchmark light dark matter models. The experiment can also probe a variety of well-motivated New Physics scenarios that will be covered in this talk, such as ALPs, inelastic DM (Eur. Phys. J. C 83 (2023) no.5, 391), B-L (Phys. Rev. Lett. 129 (2022) no.16, 161801) and L_mu - L_tau Z'bosons searches (Phys. Rev. D 106 (2022) no.3, 032015). Moreover, we will present the preliminary results of NA64 running in positron and muon modes, and discuss the future prospects of the experiment including the use of hadron beams.

Author: MOLINA BUENO, Laura (IFIC Valencia)

Presenter: MOLINA BUENO, Laura (IFIC Valencia)

Contribution ID: **57** Type: **not specified**

Hot QCD axion abundance

Tuesday, September 19, 2023 9:00 AM (30 minutes)

I will discuss recent developments on the determination of the cosmological bound on the QCD axion mass, and the challenges for a correct interpretation of future cosmological surveys.

Author: VILLADORO, Giovanni (ICTP Trieste)

Presenter: VILLADORO, Giovanni (ICTP Trieste)

Contribution ID: **58** Type: **not specified**

Atomic sensors for light new particles and high-frequency gravitational waves

Tuesday, September 19, 2023 3:30 PM (30 minutes)

In order to make the small effects of feebly interacting particles as candidates for Dark Matter or mediators to a Dark Sector detectable, novel approaches are in demand. I will present the use of cold atoms as quantum sensors for particle physics questions. In particular, I will show how the rapidly advancing precision of atomic clocks constrains light new bosons and how they could be used for the detection of high-frequency gravitational waves.

Presenter: FUCHS, Elina (CERN, Leibniz University Hannover, PTB Braunschweig)

Contribution ID: **59** Type: **not specified**

The Light Dark Matter Program at MESA

Tuesday, September 19, 2023 11:00 AM (20 minutes)

At the Institute for Nuclear Physics in Mainz the new electron accelerator MESA (Mainz Energy-recovery Superconducting Accelerator) will go into operation within the next years. MESA will provide intense electron beams for hadron and nuclear physics, as well as for light dark matter (LDM) searches. In this contribution, we will present the MAGIX and DarkMESA experiments at MESA. MAGIX, is a two-spectrometer setup coupled with a gas-jet target with a wide physics program, including LDM searches. DarkMESA is a beam-dump experiment focused on LDM searches. The status of the new facility and of the experiments will be described, together with results from prototype detectors and projected physics reach.

Author: DORIA, Luca (Johannes Gutenberg University Mainz)

Presenter: DORIA, Luca (Johannes Gutenberg University Mainz)

Contribution ID: **60** Type: **not specified**

Status of the first ALPS II science run

Tuesday, September 19, 2023 11:50 AM (10 minutes)

The Any Light Particle Search II, ALPS II, is a Light Shining through a Wall experiment at DESY in Hamburg, hunting for axions and axion-like particles in the sub-meV mass range with an axion-photon coupling gαγγ > 2 × 10−11 GeV−1, improving sensitivity by a factor of 103 compared to its predecessors. A high-power laser is directed through a long array of superconducting dipole magnets and an optical cavity, where some photons may convert into a beam of axion-like particles, exploiting the inverse-Sikivie effect. The axion beam will then pass through a light-tight barrier and enter another strong magnetic field in a second cavity, mode-matched to the cavity before the wall, where some of the axion particles can convert back into photons and be detected. The ALPS II experiment has begun the initial data acquisition phase without the cavity before the wall to optimize stray-light hunting. At this stage, the heterodyne detector (HET) scheme is implemented for the detection of regenerated photons. To confirm the results obtained with the HET, independent measurements might subsequently be conducted with the superconducting Transition Edge Sensors (TES). In this talk, we will describe the status and experience of the initial data taking with ALPS II.

Author: OCEANO, Isabella (DESY)

Presenter: OCEANO, Isabella (DESY)

Contribution ID: **61** Type: **not specified**

Minimal FIMP models during reheating and inflationary constraints

Thursday, September 21, 2023 6:00 PM (10 minutes)

We study the production of Dark Matter (DM) in a minimal freeze-in model during inflationary reheating. We analyze the case where a heavier parent particle decays into DM and a Standard Model fermion in two reheating scenarios: bosonic reheating (BR) and fermionic reheating (FR). Firstly, we show that for low reheating temperatures, BR and FR scenarios predict different lifetimes and masses for the parent particle when considering reheating potentials with power-law behavior. Additionally, we highlight how different treatments of the reheating phase and definitions of the reheating temperature in the literature can lead to conflicting conclusions about the relevance of long-lived particle (LLP) searches in testing the freeze-in model. Moreover, we investigate the interplay between LLP searches and cosmological constraints on SUGRA-motivated inflationary models, specifically
alpha-attractor E- and T-models. In essence, we find that the inflaton potential and the reheating temperature significantly affect the relic density of DM and could have crucial implications for interpreting collider signatures and understanding the dynamics of inflationary reheating.

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Production of Feebly Interacting particles at Finite Temperature

Thursday, September 21, 2023 5:40 PM (20 minutes)

Models of feebly-interacting Dark Matter (DM) have gained popularity due to the non-observation of DM in direct detection experiments. Unlike DM freeze-out, which occurs when the dark sector particles are non-relativistic, feebly-interacting DM is primarily produced at temperatures corresponding to the heaviest mass scale involved in the production process. Consequently, incorporating finite temperature corrections becomes essential for an accurate prediction of the relic density. However, current calculations are often performed at either zero temperature or rely on thermal masses to regulate infrared divergences. In our study, we utilize the Closed-Time-Path (CTP) formalism to compute the production rate of feebly-interacting DM associated with a gauge charged parent. We compare our results with the aforementioned approaches such as the insertion of thermal masses, zero temperature calculations and a recent calculation that interpolates between finite temperature results in the ultra-relativistic and non-relativistic regime. Furthermore, we discuss the applicability and feasibility of these different approaches for phenomenological studies.

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