UCLA Dark Matter 2020 Conference

Wednesday 25 March 2020 - Saturday 28 March 2020

UCLA

Book of Abstracts

Contents

Session 13 / **70**

Ultra-high radio-pure NaI(Tl) crystal growth for the SABRE experiment

Author: Aldo Aldo Ianni[None]

Corresponding Author: aldo.ianni@lngs.infn.it

The SABRE proof-of-principle (PoP) experiment aims to develop ultra-pure NaI(Tl) scintillators for direct dark matter research. The new SABRE low background NaI(Tl) crystals will be used to probe for the model independent annual modulation, expected for dark matter particles in the galactic halo. The first NaI(Tl) detector is installed underground in passive shielding at the Gran Sasso Laboratory, Italy, for preliminary crystal characterization. Measurements of radio-purity by ICP-MS and direct counting yield results for this detector with background comparable to that reported in Phase II of DAMA/LIBRA. On-going research toward further reduction of crystal radio-purity will be reported, together with a plan for future SABRE detectors in the north and south hemispheres.

Session 10 / **29**

A multicomponent dark matter scenario consistent with experiment

Author: Roland Allen[1]

[1] *Texas A&M University*

Corresponding Author: allen@tamu.edu

We review a dark matter scenario [1-6] which is consistent with recent analyses of observations from Fermi-LAT, AMS-02, and Planck. In this scenario, with both supersymmetry and an extended Higgs sector, the mass of the dominant dark matter WIMP is rigorously $\leq$ 125 GeV/c^2, its gauge couplings are precisely defined, and its Higgs-mediated couplings should be comparable to those of a neutralino. Very recent and earlier analyses of the data from Planck, Fermi-LAT, AMS-02, and other experiments indicate that (i) the positron excess at $\sim$ 800 GeV or above is not evidence of high-mass dark matter particles (which would have disconfirmed the present theory), (ii) the Galactic center excess of gamma rays observed by Fermi-LAT may be evidence for dark matter particles with a mass near or below 100 GeV, (iii) the gamma-ray excess from Omega Centauri may provide similar evidence of annihilation of such relatively low-mass particles, and (iv) the antiproton excess observed by AMS is again possible evidence of roughly 100 GeV dark matter particles. The present scenario, with two stable spin 1/2 WIMPs (a high-mass neutralino and a more abundant "Higgson") is consistent with these results, and it also suggests that true detection should be near in direct, indirect, or collider detection experiments.
[1] R. E. Allen and A. Saha, Mod. Phys. Lett. A 32, 1730022 (2017), arXiv:1706.00882 [hep-ph].
[2] Roland E. Allen, Phys. Scr. 94, 014010 (2019), arXiv:1811.00670 [hep-ph].
[3] Maxwell Throm, Reagan Thornberry, John Killough, Brian Sun, Gentill Abdulla, and Roland Allen, Mod. Phys. Lett. A 34, 1930001 (2019), arXiv:1901.02781 [hep-ph].
[4] Reagan Thornberry, Maxwell Throm, John Killough, Dylan Blend, Michael Erickson, Brian Sun, Brett Bays, Gabe Frohaug, and Roland E. Allen, submitted.
[5] Reagan Thornberry, Alejandro Arroyo, Caden LaFontaine, Gabriel Frohaug, Dylan Blend, and Roland E. Allen, eConf: The SLAC Electronic Conference Proceedings Archive, arXiv:1910.09950.
[6] Dylan Blend, Reagan Thornberry, Alejandro Arroyo, Gabriel Frohaug, Caden LaFontaine, and Roland E. Allen, proceedings of European Physical Society High Energy Physics Conference.

Session 4 / **108**

Dark Matter Detection with Liquid Xenon

Author: Elena Aprile[1]

[1] *Columbia U.*

Corresponding Author: age@astro.columbia.edu

Detection of a Dark Matter signal in an ultra-low background terrestrial detector will provide the most direct evidence of its existence and will represent a ground-breaking discovery in physics and cosmology. Among the variety of dark matter detectors, liquid xenon time projection chambers have shown to be the most sensitive, thanks to a combination of very large target mass, ultra-low background and excellent signal-to-noise discrimination. Experiments based on this technology have led the field for the past decade. I will review the world leading results achieved with the first tonne scale experiment, XENON1T, before discussing sensitivity and discovery potential of the larger XENONnT and LZ expected to become operational this year.

Session 11 / **96**

The GRAMS Project: MeV gamma-ray observations and antimatter-based indirect dark matter searches

Author: Tsuguo Aramaki[1]

[1] *SLAC*

Corresponding Author: tsuguo@slac.stanford.edu

GRAMS (Gamma-Ray and AntiMatter Survey) is a next-generation experiment that will be the first to target both MeV gamma-ray observations and antimatter-based indirect dark matter searches. With a cost-effective, large-scale LArTPC detector, a single long-duration balloon (LDB) flight can have an order of magnitude improved sensitivity to gamma rays in the poorly-explored MeV energy domain. Additionally, GRAMS has been developed to become a next-generation dark matter search experiment beyond the GAPS project for antimatter survey. The antimatter measurements can provide clean dark matter signatures while validating the possible dark matter detection suggested in the Fermi gamma-ray observations and the AMS-02 antiproton measurements. In this talk, I will start with the overview of the project and then focus on the detection concepts for MeV gamma rays and antiparticles.

Session 6 / **21**

The Hubble tension: implications for dark matter and dark energy

Authors: Nikki Arendse[1]; Radek Wojtak[1]; Adriano Agnello[None]; Geoff Chen[None]; Christopher Fassnacht[None]; Dominique Sluse[None]; Stefan Hilbert[None]; Martin Millon[None]; Vivien Bonvin[None]; Kenneth Wong[None]; Frédéric Courbin[None]; Sherry Suyu[None]; Simon Birrer[None]; Tommaso Treu[None]; Leon Koopmans[None]

[1] *DARK, University of Copenhagen*

Corresponding Author: nikki.arendse@nbi.ku.dk

Persistent tension between low-redshift observations and the Cosmic Microwave Background radiation (CMB) suggests residual systematics or new physics beyond the standard LCDM model. Local observations of baryon acoustic oscillations with low-redshift distance calibrators can constrain the

value of the Hubble constant and the sound horizon in a cosmologically independent way. When compared to the values inferred from the CMB, a tension up to 5 sigma arises. Several modifications of LCDM, either before or after recombination, have been put forward to reconcile the tension, but it is not clear how well these models actually perform. In my presentation, I will talk about the current status of tensions between the CMB-based and local (based on gravitational time delays and classical distance ladder) distance calibrations. I will also critically review most popular extensions of LCDM proposed to reconcile these measurements.

Session 16 / **68**

EDELWEISS : direct searches for sub-GeV dark matter with cryogenic Ge detectors

Author: Quentin ARNAUD[1]

[1] *IP2I*

Corresponding Author: q.arnaud@ipnl.in2p3.fr

The EDELWEISS direct detection experiment uses cryogenic Ge semiconductor detectors equipped with NTD thermal sensors to search for sub-GeV dark matter particles. In this presentation, I give an overview of our most recent results from searches for SIMPs and electron-scattering dark matter, using massive ˜30 g Ge detectors operated both at the surface and at the LSM underground laboratory, respectively. The emphasis is given to the latter search where a charge resolution of ~0.5 electron-hole pair (RMS) is achieved through Luke-Neganov amplification of the phonon signal at 78 V. We exploit the resulting sensitivity to energy deposits as low as the band gap energy (0.67 eV) to derive experimental constraints on dark matter particles interacting with electrons down to a 0.5 MeV/c² mass. These results are competitive with other state-of-the-art approaches and improve upon existing constraints from phonon-mediated cryogenic detectors.

6

Gravity safe, electroweak natural axionic\\ solution to strong CP and SUSY μ problems

Author: Howard Baer[1]

[1] *University of Oklahoma*

Corresponding Author: baer@nhn.ou.edu

Particle physics models with Peccei-Quinn (PQ) symmetry breaking
as a consequence of supersymmetry (SUSY) breaking are attractive in that
they solve the strong CP problem with a SUSY DFSZ-like axion,
link the SUSY breaking and PQ breaking intermediate mass scales
and can resolve the SUSY μ problem with a naturalness-required
weak scale μ term whilst soft SUSY breaking terms inhabit the
multi-TeV regime as required by LHC sparticle mass limits and
the Higgs mass measurement.
On the negative ledger, models based on global
symmetries suffer a generic gravity spoliation problem.
We present two models based on the discrete R-symmetry
$\mathbf{Z}_{24}^R$– which may emerge
from compactification of 10-d Lorentzian spacetime in string theory–
where the μ term and dangerous proton decay and R-parity
violating operators are either suppressed or forbidden
while a gravity-safe PQ symmetry emerges as an accidental approximate

global symmetry leading to a solution to the strong CP problem
and a weak-scale/natural value for the μ term.

Session 10 / **32**

Supersymmetric dark matter candidates: wimps and axions

Author: Howard Baer[1]

[1] *University of Oklahoma*

Corresponding Author: baer@nhn.ou.edu

In this talk I will review the present status of supersymmetric dark matter candidates for 2020, in light of recent LHC and wimp direct detection limits.
Naturalness in the EW sector implies higgsino-like LSPs which are thermally underproduced while naturalness in the QCD sector seems to require the axion.
In fact, SUSY helps solve a major problem for axions: it can generate the needed global PQ as an accidental, approximate symmetry from an underlying Z24R symmetry which may emerge from compactification of the underlying 10-d Lorentz symmetry
of string theory. Then there is a common origin for both PQ symmetry and R-parity,
and a natural solution to the SUSY mu problem via SUSY DFSZ axions.
Dark matter production is calculated via eight coupled Boltzmann equations tracking wimps, axions, axinos, saxions, gravitinos and radiation. While axions typically comprise the bulk of dark matter, their coupling is diminished by the presence of higgsinos in the agammagamma coupling. However, prospects for direct detection are good for multi-ton noble liquid detectors, even though wimps typicaly constitute only about 10% of dark matter.

Session 15 / **59**

Dark matter and neutrino physics with DARWIN

Author: Laura Baudis[1]

[1] *University of Zurich*

Corresponding Author: lbaudis@physik.uzh.ch

Two of the outstanding open questions in physics are the nature of dark matter and the fundamental nature of neutrinos. DARWIN is a next-generation experiment aiming to reach a dark matter sensitivity limited by the irreducible neutrino backgrounds. The core of the detector will have a 40 ton liquid xenon target operated as a dual-phase time projection chamber. The unprecedented large xenon mass, the exquisitely low radioactive background and the low energy threshold will allow for a diversification of the physics program beyond the search for dark matter particles: DARWIN will be a true low-background, low-threshold astroparticle physics observatory. I will present the status of the project, its science reach, and discuss the main R&D topics.

Session 7 / **81**

The Migdal Effect: I'll believe it when I see it

Author: Daniel Baxter[1]

[1] *University of Chicago*

Corresponding Author: dbaxter@uchicago.edu

The Migdal Effect has seen a surge of interest in the last three years, particularly since Ibe et al (1707.07258) laid out the formalism for how to calculate an expected rate in a detector due to a dark matter signal. Multiple groups since then have expanded on this theoretical work to demonstrate the importance of such a signal in searching for sub-GeV dark matter, but all suffer from the same problem: a lack of experimental measurement to validate the calculation. I lay out the importance of measuring the Migdal effect through nuclear recoil calibrations, what sort of signal to expect in such a calibration, and why this question is particularly interesting for existing and upcoming semiconductor experiments with single electron thresholds.

Session 12 / **49**

Results on annual modulation by DAMA/LIBRA-phase2

Authors: Pierluigi Belli[1]; for DAMA collaboration[None]

[1] *INFN - Roma Tor Vergata*

Corresponding Author: pierluigi.belli@roma2.infn.it

The results of the first 6 independent annual cycles of DAMA/LIBRA–phase2 experiment deep underground at Gran Sasso are summarized; they correspond to a total exposure of 1.13 ton × yr. The DAMA/LIBRA–phase2, with lower energy threshold with respect to phase1, confirms the evidence of a signal that meets all the requirements of the model independent Dark Matter annual modulation signature, at high C.L. The model independent DM annual modulation result is compatible with a wide set of DM candidates. In this talk we summarize some of them and perspectives for the future will be outlined.

Session 5 / **9**

From Dark Matter Particle Phenomenology to Astrophysical Structure Formation

Author: Andrew Benson[None]

Corresponding Author: abenson@carnegiescience.edu

Constraining the particle properties of dark matter from astronomical observables requires detailed forward modeling that can connect those two regimes. I will discuss recent progress in implementing generic dark matter phenomenology (e.g. cut-offs in the power spectrum, self-interactions) into models of structure and galaxy formation - in particular in the context of fast and flexible semi-analytic models. I will focus on the range of observable quantities that can be predicted by such models, and the precision and robustness that can be achieved.

RECEPTION and POSTER SESSION IN THE SAME ROOM / **132**

Status and plans for the NA64 experiment at CERN

Author: Johannes Bernhard[1]

[1] *CERN*

Corresponding Author: johannes.bernhard@cern.ch

The NA64 experiment at CERN searches for dark matter produced in both visible and invisible decays of sub-GeV vector mediators, for instance the dark photon A'. In a first data taking period from 2016-2018, A'production from the reaction e–Z → e–ZA′ and subsequent decays A'→χχ and A'→ e+e– was studied with the help of an active dump experiment using 100 GeV/c electrons. Recently, an extension of the performed searches was proposed using a 150 GeV/c muon beam, available at the M2 beam line at CERN. These measurements would allow for additional coverage of parameter space towards higher A'masses and would open the possibility for searches for a possible Zμ that would couple only to second and third generation leptons. We will present both the analysis of the available NA64 data with an emphasis on the search for a possible X(17) boson as well as future plans for searches with muon and electron beams that are proposed within the "Physics Beyond Colliders"framework at CERN, including optimisation of the M2 optics and integration studies for implementing NA64μ in the EHN2 experimental area.

RECEPTION and POSTER SESSION IN THE SAME ROOM / 91

Iron filter designs for portable, monoenergetic 24 keV neutron calibration sources

Author: Andreas Biekert[1]

Co-authors: Ethan Bernard [1]; Madeline Bernstein [1]; Scott Hertel ; Junsong Lin [2]; Daniel Mckinsey ; Pratyush Patel [3]; Harold Pinckney [4]; Roger Romani [1]; Alessandro Serafin [5]; Ryan Smith [1]; Burkhant Suerfu [1]; Vetri Velan [1]; Lanqing Yuan [1]

[1] *University of California, Berkeley*

[2] *University of California Berkeley*

[3] *University of Massachusetts Amherst*

[4] *University of Massachusetts at Amherst*

[5] *University of Massachusetts*

Corresponding Author: biekerta@berkeley.edu

Searches for light (<1 GeV) dark matter are mainly limited by detector sensitivity to low energy deposits. Accurately characterizing dark matter detector thresholds calls for calibration sources that produce well-understood low energy neutron spectra and that are convenient to use. For low energy nuclear recoils, two existing strategies to produce monoenergetic neutrons are photoneutron sources and filtered neutron sources. Photoneutron sources are generally compact and transportable. However, the low cross section for neutron production introduces a large population of background gammas that requires extra shielding material to mitigate. An alternative is the use of a filter material with a notch in its cross section–a narrow region in neutron energy where the material has a decreased scattering cross section. Combined with a broadband neutron source, typically from a reactor, the filter preferentially transmits neutrons with energies in the notch. We present two source designs that leverage these concepts, using a long rod of natural iron as a filter for portable, monoenergetic neutron calibration sources. Neutrons produced by the SbBe photoneutron reaction have an energy of 24.5 keV, which coincidentally overlaps almost perfectly with a notch in the cross section of ^{56}Fe at a neutron energy of 24 keV. The source provides a relatively high total flux of about 10^5 neutrons per second with a GBq-scale ^{124}Sb source, while the background gamma rate can be controlled with a combination of the iron filter technique and traditional gamma shielding materials such as lead and tungsten. We also present a filtered source design based on the deuterium-tritium fusion neutron process, where the 14.2 MeV neutrons are moderated using fluental and eventually filtered with natural iron. Simulations for both source designs suggest they yield excellent neutron purity and serve as directional sources of 24 keV neutrons. In both cases, it is possible to turn the neutron flux on and off, improving their practicality for detector calibrations. The design, simulation analysis, and current status of both source concepts will be discussed.

Session 14 / **72**

Dark Matter-Electron Scattering from Aromatic Organic Targets

Author: Carlos Blanco[1]

[1] *University of Chicago*

Sub-GeV dark matter (DM) which interacts with electrons can excite electrons occupying molecular orbitals in a scattering event. In particular, aromatic compounds such as benzene or xylene have an electronic excitation energy of a few eV, making them sensitive to DM as light as a few MeV. These compounds are often used as solvents in organic scintillators, where the de-excitation process leads to a photon which propagates until it is absorbed and re-emitted by a dilute fuor. The fuor photoemission is not absorbed by the bulk, but is instead detected by a photon detector such as a photomultiplier tube. We develop the formalism for DM{electron scattering in aromatic organic molecules, calculate the expected rate in p-xylene, and apply this calculation to an existing measurement of the single photo-electron emission rate in a low-background EJ-301 scintillator cell. Despite the fact that this measurement was performed in a shallow underground laboratory under minimal overburden, the DM{electron scattering limits extracted from these data are already approaching leading constraints in the 3{100 MeV DM mass range. We discuss possible next steps in the evolution of this direct detection technique, in which scalable organic scintillators are used in solid or liquid crystal phases and in conjunction with semiconductor photodetectors to improve sensitivity through directional signal information and potentially lower dark rates.

Session 6 / **18**

Implications of the Gaia anisotropic substructure for direct detection

Authors: Nassim Bozorgnia[None]; Azadeh Fattahi[1]; Carlos Frenk[1]; Andrew Cheek[2]; David Cerdeno[1]; Facundo Gomez[3]; Robert Grand[4]; Federico Marinacci[5]

[1] *Durham University*

[2] *Louvain University*

[3] *La Serena University*

[4] *Max Planck Institute, Garching*

[5] *Bologna University*

Corresponding Author: nassimb@yorku.ca

A prominent population of stars with a high radial velocity anisotropy has recently been discovered in the inner stellar halo, using the second data release from the Gaia satellite. An important question regarding this stellar structure, is the properties of its unknown dark matter component in the Solar neighborhood. Determining the fraction and anisotropy of this dark matter component is especially important for the interpretation of direct detection results, which strongly depend on the local dark matter distribution. I will discuss the properties of the dark matter component of the Gaia anisotropic substructure, using the Auriga magneto-hydrodynamical simulations of galaxy formation. In particular, I will present the local dark matter density and velocity distribution of the simulated Milky Way-like halos with and without the anisotropic substructure, and discuss their implications for dark matter direct detection.

Session 8 / **40**

The Heavy Photon Search Experiment

Author: Cameron Bravo[1]

[1] *SLAC*

Corresponding Author: c.bravo@cern.ch

The Heavy Photon Search (HPS) experiment searches for electro-produced dark photons using an electron beam provided by the CEBAF accelerator at the Thomas Jefferson National Accelerator Facility. A search for e+e- resonances in the invariant mass distribution has sensitivity to dark photons with larger coupling, while the additional requirement of a displaced vertex to identify long-lived dark photons adds sensitivity at smaller couplings beyond the reach of most other experiments. HPS employs a compact spectrometer, matched to the forward kinematic characteristics of A'electro-production. The detector consists of a silicon tracker for momentum analysis and vertexing and a lead tungstate (PbWO4) electromagnetic calorimeter for particle ID and triggering. HPS completed a successful engineering run in 2015, collecting 1.7 days of data (10 mC) at 1.056 GeV beam energy, and again in 2016, collecting 5.4 days of data (92.5 mC) at 2.3 GeV beam energy. Results from the 2015 engineering run have demonstrated the full functionality of the experiment, while results from the 2016 dataset are nearing completion. Subsequent to 2016 operations, a small upgrade of the detector was completed in advance of a run in the summer/fall of 2019, collecting roughly two weeks of data at 4.55 GeV. The status of all ongoing analysis will be discussed, along with perspectives on the 2019 dataset and future operations.

Session 1 / **36**

Interpreting Dwarf Galaxies and Dark Matter

Author: Alyson Brooks[1]

[1] *Rutgers, the State University of New Jersey*

Corresponding Author: abrooks@physics.rutgers.edu

Immense progress has been made in the last decade in simulating and understanding the role that baryons have in influencing the evolution and structure of dark matter on small scales and in dwarf galaxies. In this talk I will review the successes in modeling small scales and discuss the implications for interpreting the dark matter model. I will also highlight some remaining challenges and open questions.

RECEPTION and POSTER SESSION IN THE SAME ROOM / **133**

Multiphonon excitations from dark matter scattering in crystals

Author: Brian Campbell-Deem[1]

[1] *University of California, San Diego*

Corresponding Author: bccampbe@ucsd.edu

For direct detection of sub-MeV dark matter, a promising strategy is to search for individual phonon excitations in a crystal. We perform an analytic calculation of the rate for light dark matter (keV < mDM < MeV) to produce two acoustic phonons through scattering in cubic crystals such as GaAs, Ge, Si and diamond. The multiphonon rate is always smaller than the rate to produce a single optical phonon, whenever the latter is kinematically accessible. In Si and diamond there is a dark matter mass range for which multiphonon production can be the most promising process, depending on the experimental threshold.

Session 16 / **62**

Low-mass Dark Matter Search with the CRESST-III Experiment

Author: Lucia Canonica[1]

[1] *Max-Planck-Institut für Physik*

Corresponding Author: canonica@mpp.mpg.de

CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) is a direct dark matter search experiment located at the Gran Sasso underground Laboratory (LNGS, Italy). Scintillating CaWO4 crystals, operated as cryogenic calorimeters at millikelvin temperature, are used as target material for elastic DM-nucleus scattering. The experiment, optimized for low-energy nuclear recoil detection, reached an unprecedented threshold of 30 eV for nuclear recoil energies and it is currently leading the field of low-mass dark matter search, for values below 1.6 GeV/cˆ2.
In this contribution, the current stage of the CRESST-III experiment, together with the most recent dark matter results will be presented. The perspective for the next phase of the experiment will be also discussed.

Session 13 / **38**

Analysis of High Energy Events and Neutrinoless Double Beta Decay in XENON1T

Authors: Chiara Capelli[None]; On behalf of the XENON collaboration[None]

Corresponding Author: chiara@physik.uzh.ch

The XENON1T experiment searches for Weakly Interacting Massive Particles (WIMPs) with a dual-phase xenon Time Projection Chamber (TPC). To extend its physics reach, the efforts of the XENON collaboration are directed toward exploring other detection channels. For this purpose, considerable work on the signal reconstruction and data analysis has been done to extend the available energy range up to 3 MeV, two orders of magnitude higher than the standard WIMP analysis. This would allow one to search for the neutrinoless double beta decay of ^{136}Xe, which is fundamental to probing the Majorana nature of neutrinos and solving the hierarchy problem. The achievements and future prospects for the high energy analysis with dual-phase TPCs will be presented.

Session 13 / **85**

Dark Matter Search with SuperCDMS eV-resolution Device

Author: Yen-Yung Chang[1]

[1] *California Institute of Technology*

Corresponding Author: yychang@caltech.edu

We report the final dark matter (DM) search results and background spectrum measurement from a 1.2 g·day exposure of an upgraded SuperCDMS high-voltage eV-resolution (HVeV) detector. The 1×1×0.4 cm³ (0.93 g) HVeV detector is able to detect single electron-hole pair production by sensing phonons produced by the Neganov-Trofimov-Luke effect at a voltage bias of 100 V. Relative to the first run of a HVeV detector, a revised phonon sensor design improves the phonon energy resolution from 14 eV to 3 eV, achieving 3% energy resolution for detection of one electron-hole pair. Furthermore, the laser energy calibration scheme now accounts for photons directly absorbed in the phonon sensor, and the detector response model was improved by incorporating charge carrier

trapping and impact ionization. We use data division to blind our DM search. We report constraints on DM-electron scattering for 0.5-10⁴ MeV DM mass, dark photon absorption for 0.3-50 eV mass, and, for the first time, constraints on galactic axion-like particle absorption for 0.3-50 eV mass.

RECEPTION and POSTER SESSION IN THE SAME ROOM / 125

A New Formation Channel for Globular Clusters

Author: Yeou Chiou[1]

[1] *UCLA*

Corresponding Author: yschiou@physics.ucla.edu

The puzzling origins of globular clusters have been greatly debated over the years. I will present a new formation channel for globular clusters, linking them to objects that formed without dark matter in the early Universe in the presence of the stream velocity. This stream velocity (Tseliakhovich & Hirata 2010) arises due to the drop in radiation pressure of baryons from matter-radiation decoupling and induces a phase shift/physical separation between dark matter and baryonic overdensity peaks (Naoz & Narayan 2014). This effect gives rise to gas dominant objects with little to no dark matter. These gas-rich structures, called Supersonically Induced Gas Objects (SIGOs), form naturally outside of dark matter halos as a consequence of the stream velocity. Running hydrodynamic AREPO simulations we find that SIGOs density is high enough to allow stars to form. Then, we model the star formation process and estimate the luminosity of the first star clusters within a SIGO. We find that SIGOs occupy a different part of the luminosity-mass parameter than classical, dark matter halos with gas. SIGOs are dimmer and have globular cluster-like masses. We further adopt a simple model to evolve the SIGOs to current day objects and show that their radius and luminosity is consistent with present-day (local) globular clusters. Since the relative velocity between the baryons and dark matter is coherent over a few Mpc scales, we predict that if this is the dominant mechanism for globular clusters, their abundance should vary significantly over these scales.

Session 10 / 61

Axiogenesis and Kinetic Misalignment Mechanism

Author: Raymond Co[1]

Co-authors: Keisuke Harigaya [2]; Lawrence Hall [3]

[1] *University of Michigan*

[2] *IAS*

[3] *U.C. Berkeley*

Corresponding Author: rtco@umich.edu

We proposed a mechanism called axiogenesis to explain the observed cosmological excess of matter over antimatter. A rotation of the QCD axion is induced by explicit Peccei-Quinn symmetry breaking in the early universe. The rotation corresponds to the asymmetry of the PQ charge, which is converted into the baryon asymmetry via QCD and electroweak sphaleron transitions. Such a rotation also gives rise to a new origin of axion dark matter, which we call the kinetic misalignment mechanism. The concrete model we explore predicts a small decay constant and has close connections with axion dark matter and new physics at the colliders. These ideas arise from complimentary and well-motivated axion initial conditions, expanding the parameter space to the regions of interest for the extensive experimental searches.

Session 14 / **83**

Scintillating Bubble Chambers for GeV WIMPs and reactor CEvNS

Authors: Rocco Coppejans[1]; C Eric Dahl[1]

[1] *Northwestern University*

Corresponding Author: rocco.coppejans@gmail.com

The Scintillating Bubble Chamber (SBC) is a rapidly developing new technology for sub-keV nuclear recoil detection. Demonstrations in liquid xenon at the few-gram scale have confirmed that this technique combines the event-by-event energy resolution of a liquid-noble scintillation detector with the world-leading electron-recoil discrimination capability of the bubble chamber, and in fact maintains that discrimination capability at much lower thresholds than traditional Freon-based bubble chambers. The promise of unambiguous identification of sub-keV nuclear recoils in a scalable detector makes this an ideal technology for both GeV-mass WIMP searches and CEvNS detection at reactor sites. We will present progress from the SBC Collaboration towards the construction of a pair of 10-kg argon bubble chambers at Fermilab and SNOLAB, to test the low-threshold performance of this technique in a physics-scale device and to search for 0.7 - 7 GeV dark matter, respectively.

RECEPTION and POSTER SESSION IN THE SAME ROOM / **53**

Axion-like Particles from Core-collapse Supernovae: Investigating Fermi's Sensitivity

Author: Milena Crnogorcevic[1]

Co-authors: Regina Caputo [2]; Manuel Meyer [3]

[1] *University of Maryland College Park, NASA/GSFC*

[2] *GSFC/UMCP*

[3] *Stanford University*

Corresponding Author: mcrnogor@astro.umd.edu

Axion-like particles (ALPs) are a well-motivated candidate for constituting a significant fraction of cold dark matter in the Universe. They are hypothesized to be produced in high-energy environments, such as core-collapse supernovae (CCSNe), and could undergo conversion into gamma-rays in the presence of an external magnetic field, spectrally peaking at ˜60 MeV. CCSNe are often invoked as progenitors of long gamma-ray bursts (LGRBs), allowing us to conduct a search for potential ALP spectral signatures using GRB observations with *Fermi* Large Area Telescope (LAT). In this project, we conduct a data-driven sensitivity analysis to find the distance limit for a hypothetical ALP detection with LAT. Furthermore, we select a sample of twenty-four unassociated LGRBs and carry out a model comparison analysis, in which we consider different GRB spectral models with and without an ALP spectral component. We find that the addition of an ALP component does not result in a statistically significant improvement. In this presentation, we will summarize the statistical methods used in our analysis and the underlying physical assumptions, the feasibility of the upper limits on ALP coupling from our model comparison results, and an outlook on future MeV instruments.

Session 11 / **58**

Gravitational probes of exotic compact objects

Author: Djuna Croon[1]

[1] *TRIUMF*

Corresponding Author: dcroon@triumf.ca

In this talk I will discuss experimental probes of dark compact objects in the new era of gravitational wave astrophysics. Such proposed objects include scalar (boson) stars, Q-balls, and dark matter clumps inside neutron stars. I will review the properties that will help us distinguish them from astrophysical objects, and the resulting gravitational wave phenomenology. I will also discuss connections with other astrophysical probes, such as gravitational (micro)lensing.

Session 10 / **128**

Axion strings and axion dark matter

Author: Yanou Cui[1]

[1] *University of California, Riverside*

Corresponding Author: yocui08@gmail.com

to be added

Session 12 / **51**

The SuperCDMS SNOLAB Experiment

Author: Priscilla Cushman[1]

[1] *University of Minnesota*

Corresponding Author: cushman@umn.edu

The SuperCDMS SNOLAB experiment will probe a range of low-mass dark matter models with a suite of silicon and germanium detectors operated in both high-voltage and nuclear-recoil-discrimination modes. Plans for nuclear recoil yield measurements and our 4-tower initial payload strategy will be presented, as well as our expected physics reach for the first science run and beyond.

Session 5 / **17**

Constraining dark matter models with strong gravitational lensing and simulations

Author: Giulia Despali[1]

[1] *Max Planck Institute for Astrophysics*

Corresponding Author: gdespali@mpa-garching.mpg.de

Strong gravitational lensing is one of the most accurate methods to measure the mass of galaxies and haloes and one of the most promising to investigate the nature of dark matter. Given that the abundance of small-mass and dark clumps is very different in cold and warm dark matter model, this kind of observations can put important constraints on the nature of dark matter, through the detection of

small-scale perturbations of the surface brightness distribution of lensed arcs. In order to meaningfully interpret observational results, we derived detailed predictions for the detection expectations in different dark matter scenarios, using theoretical models and numerical simulations. In particular, I will present predictions for future observations, quantifying how many lenses and which resolution we would need to put stringent constraints on the nature of dark matter and discriminate CDM from WDM, considering both substructures and haloes along the line-of-sight as sources of perturbation. Moreover, I will present results coming from high resolution hydrodynamical simulations run with sterile neutrino warm dark matter and self-interacting dark matter, showing what is the effect of each of these models on the properties of the lens galaxies, the lensing signal and the abundance of low-mass (sub)haloes.

Session 5 / **39**

Review of recent dark matter searches from the Fermi-LAT Collaboration

Author: MATTIA DI MAURO[1]

[1] *NASA'S GODDARD SPACE FLIGHT CENTER AND CUA*

Corresponding Author: dimauro.mattia@gmail.com

Fermi-LAT has revolutionized our understanding of the gamma-ray sky from hundreds of MeV up to almost TeV energies. One of the main scientific goals of the LAT Team is to search for a dark matter production of gamma rays. This search is performed by analyzing the data in the direction of the most promising dark matter targets: the Galactic center, Milky Way Dwarf Spheroidal Galaxies, the closest galaxies as Triangulum and Andromeda and the Small and the Large Magellanic cloud. In this talk I will present the latest Fermi-LAT Collaboration results and future strategies for dark matter searches with gamma-ray data.

RECEPTION and POSTER SESSION IN THE SAME ROOM / **131**

Systematic errors in strong gravitational lensing reconstructions, a numerical simulation perspective.

Author: Wolfgang Enzi[1]

[1] *MPA- Garching, Germany*

Corresponding Author: enzi@mpa-garching.mpg.de

We present the analysis of a sample of twenty-four galaxy-galaxy strong gravitational lens systems with a background source and deflectors from the Illustris-1 simulation. We create mock lensing observations with a data quality comparable to known samples such as the SLACS lenses, to study the degeneracy between the complex mass distribution of the lenses, subhaloes, the surface brightness distribution of the sources, and the time delays. Using a novel inference framework based on Approximate Bayesian Computation, we find that for all the considered lens systems, an elliptical and cored power-law mass density distribution provides a good fit to the data. However, due to the presence of cores in the simulated lenses, most reconstructions are affected by some form of the Source Position Transformation. The latter leads to a systematic underestimation of the source sizes by 50 percent on average, and a fractional error in the Hubble constant of 36 percent. On the other hand, we find no degeneracy between complexity in the lensing potential and the inferred amount of substructure. We recover an average total projected mass fraction in subhaloes of $f_{\rm sub} < 1.7 - 2.0 \times 10^{-3}$ at the 68 percent confidence level which is consistent with zero and in agreement with the fact that all subhaloes had been removed from the simulation. Our work highlights the need for even

higher-resolution simulations to quantify the lensing effect of more realistic galactic potentials better. Finally, our results confirm that additional observational constraints may be required to break existing degeneracies.

Session 6 / **19**

Can tides disrupt cold dark matter subhaloes?

Author: Raphaël Errani[1]

Co-author: Jorge Penarrubia

[1] *University of Victoria*

Corresponding Author: errani@uvic.ca

The clumpiness of dark matter on sub-kpc scales is highly sensitive to the tidal evolution and survival of subhaloes. In agreement with previous studies, we show that N-body realisations of cold dark matter subhaloes with centrally-divergent density cusps form artificial constant-density cores on the scale of the resolution limit of the simulation. These density cores drive the artificial tidal disruption of subhaloes. We run controlled simulations of the tidal evolution of a single subhalo where we repeatedly reconstruct the density cusp, preventing artificial disruption. This allows us to follow the evolution of the subhalo for arbitrarily large fractions of tidally stripped mass. Based on this numerical evidence in combination with simple dynamical arguments, we argue that cuspy dark matter subhaloes cannot be completely disrupted by smooth tidal fields. Modelling stars as collisionless tracers of the underlying potential, we furthermore study the tidal evolution of Milky Way dwarf spheroidal galaxies. Using a model of the Tucana III dwarf as an example, we show that tides can strip dwarf galaxies down to sub-solar luminosities. The remnant 'micro-galaxies' would appear as co-moving groups of metal-poor, low-mass stars of similar age, embedded in sub-kpc dark matter subhaloes.

Session 4 / **112**

New ideas for Sub-GeV dark matter direct detection

Corresponding Author: rouven.essig@stonybrook.edu

Session 3 / **105**

Dark Sector Searches at Accelerators

Author: Jonathan Lee Feng[1]

[1] *University of California Irvine (US)*

Corresponding Author: jlf@uci.edu

The generalization of dark matter to dark sectors, with potentially rich matter content and interactions, has opened up new avenues for detection. In particular, there are now many new motivations for light, long-lived particles, which can be probed by novel experiments at accelerators. I will review these motivations, describe of the interplay of theory and experiment in this area, and give an overview of some of the new experimental developments.

RECEPTION and POSTER SESSION IN THE SAME ROOM / 73

Astrophysical Simulations of Frequent Self-Interactions

Author: Moritz Fischer[1]

Co-authors: Marcus Brüggen [2]; Kai Schmidt-Hoberg [3]

[1] *Universität Hamburg (UHH)*

[2] *Hamburger Sternwarte*

[3] *DESY*

Corresponding Author: moritz.fischer@uni-hamburg.de

Self-interacting dark matter (SIDM) is promising to solve or at least mitigate small-scale problems of cold dark matter. Simulations have proven to be a powerful tool to study SIDM within the astrophysical context. However, it turned out to be difficult to model all dark matter models with high fidelity. Models with a differential cross-section very pointed into the forward direction, for example, light mediator models, are challenging to model numerically. We develop a novel numerical scheme that is capable of modeling this small-angle scattering faithfully within the N-body method. Therefore, we introduce a drag force as an effective description of the frequent scattering. Besides, we demonstrate that we accurately model frequent scattering. In the future, we aim to combine our scheme with the widely used Monte-Carlo approach for rare scattering to be capable of simulating light mediator models within the astrophysical context with unprecedented accuracy.

Session 11 / 24

Dark Stars: the First Stars Powered by Dark Matter

Author: Katherine Freese[1]

[1] *University of Michigan*

Corresponding Author: ktfreese@umich.edu

Title: Dark Stars

Abstract: The first phase of stellar evolution in the history of the
Universe may be Dark Stars (DS), powered by dark matter heating rather than
by nuclear fusion. Weakly Interacting Massive Particles which can be their own antipartners can collect inside the first stars and annihilate to produce
a heat source that powers the stars. Alternatively, Self Interacting Dark Matter can also heat the star. A new stellar phase results, a Dark Star, which lasts as long as there is dark matter fuel, with lifetimes from millions to billions of years. Dark Stars, while made primarily of hydrogen and helium, are powered by dark matter. They are very bright diffuse puffy objects and grow to be very massive. In fact, they can grow up to ten million solar masses with up to ten billion solar luminosities. Such objects can be seen in James Webb Space Telescope. Once the dark matter fuel is exhausted, the DS becomes a heavy main sequence star and eventually collapses to form massive black holes that may provide seeds for supermassive black holes observed at early times as well as in galaxies today. We have studied pulsations of Dark Stars as an interesting observable.

Session 3 / 106

Sterile Neutrinos, Dark Matter, and the Dark Sector

Author: George Fuller[1]

[1] *UC San Diego*

Corresponding Author: gfuller@physics.ucsd.edu

Electroweak singlets, sterile neutrinos, remain viable dark matter candidates. It is tantalizing that much remains mysterious about the physics of the neutrino sector. Luckily, neutrinos impact key issues in cosmology and compact objects, and new physics in this sector therefore may reveal itself. Moreover, the advent of new neutrino experiments, and planned next generation X-ray observatories, promise to close in definitively on the issue of sterile neutrino dark matter.

Session 4 / **110**

Direct Detection with Argon

Corresponding Author: galbiati@princeton.edu

Overview of direct dark matter experiments using argon as target.

Session 15 / **79**

The XENONnT Dark Matter Search Experiment

Author: Fei Gao[1]

[1] *Columbia University*

Corresponding Author: feigao.ge@gmail.com

To date, dark matter has only been observed through its gravitational interaction. A new detector in the XENON family, XENONnT, is being constructed at the INFN Gran Sasso National Laboratory in Italy, featuring a 6 tonnes of liquid xenon target contained in a larger time projection chamber. The large target mass and approximately 10 times lower background than its predecessor XENON1T, will increase its sensitivity to WIMPs by one order of magnitude with a WIMPs-nucleon cross section down to $2 \times 10^{-48}\mathrm{cm}^2$. This talk will introduce the XENONnT experiment, explain its background budget, and present its WIMPs discovery potential.

Session 13 / **60**

DArT in ArDM, a new detector to measure ultra-low radioactive-isotope contamination of argon

Author: Pablo Garcia Abia[1]

[1] *CIEMAT*

Corresponding Author: pablo.garcia@ciemat.es

Liquid argon targets in WIMP search detectors provide outstanding separation between nuclear and electron recoil signals via pulse-shape discrimination of the scintillation signals. Atmospheric argon (AAr), however, has a naturally occurring radioactive isotope, ^{39}Ar, a β emitter of cosmogenic origin. For large detectors, the atmospheric ^{39}Ar activity poses pile-up concerns. The use of argon extracted from underground wells, deprived of ^{39}Ar, is key to the physics potential of these experiments. The DarkSide-20k dark matter search experiment will operate a dual-phase time projection chamber with

50 tonnes of radio-pure underground argon (UAr), that was shown to be depleted of ^{39}Ar relative to AAr by a factor larger than 1400. Assessing the ^{39}Ar and ^{85}Kr content of the UAr during extraction is crucial for the success of DarkSide-20k, as well as for future experiments of the Global Argon Dark Matter Collaboration (GADMC). This will be carried out by the DArT in ArDM experiment, a small chamber made with extremely radio-pure materials that will be placed at the centre of the ArDM detector, in the Canfranc Underground Laboratory (LSC) in Spain. The ArDM liquid argon volume acts as an active veto for background radioactivity, mostly γ-rays from the ArDM detector materials and the surrounding rock. This talk describes the DArT in ArDM project, including the chamber design and construction, and reviews the expected performance of the detector.

Welcome / **114**

Brief welcome and some organizational remarks

Corresponding Author: gelmini@physics.ucla.edu

Session 5 / **92**

Constraints on the free-streaming length of dark matter and halo concentrations with quadruple-image strong gravitational lenses

Authors: Daniel Gilman[1]; Simon Birrer[None]; Anna Nierenberg[None]; Tommaso Treu[None]; Andrew Benson[None]; Xiaolong Du[None]

[1] *UCLA*

The particle nature of dark matter determines the abundance and density profiles of dark matter halos. On sub-galactic mass scales differences between various dark matter models become especially pronounced. Strong gravitational lensing by galaxies offers a direct probe of dark matter structure in this low-mass regime where halos contain little to no stars, and are therefore invisible. I will describe how dark matter structure affects the observables in strong lens systems, and recent constraints on the free-streaming length of dark matter and the mass of a thermal relic dark matter particle from a joint analysis of eight quadruply-imaged quasars.

Session 16 / **34**

The search for light dark matter with NEWS-G

Author: Guillaume Giroux[1]

[1] *Queen's University*

Corresponding Author: squirrelgui@gmail.com

The NEWS-G (New Experiments With Spheres –Gas) collaboration searches for light dark matter using spherical proportional counters (SPCs) located in deep underground laboratories. A choice of light gas targets (Ne, He, H) in conjunction with sub-KeV nuclear recoil thresholds allow for sensitivity to low-mass WIMPs (Weakly Interacting Massive Particles) down to 0.1 GeV/cˆ2. The recent results from SEDINE, a 60-cm diameter SPC located at LSM (Laboratoire Souterrain de Modane), set new constraints for WIMP masses lighter than 0.6 GeV/cˆ2. The principle of operations, a description of the 140cm diameter detector with compact shielding and with projected sensitivity will be presented. Preliminary results obtained with a temporary shield at the underground laboratory of

Modane (LSM, France) with neon and methane as target gases will also be presented. Installation is ongoing in SNOLAB (Canada) and commissioning is expected in April 2020.

Session 13 / **35**

Searching for dark matter with PICO bubble chambers

Author: Guillaume Giroux[1]

[1] *Queen's University*

Corresponding Author: squirrelgui@gmail.com

The PICO collaboration searches for dark matter particles using superheated fluid detectors, or bubble chambers, filled with fluorine-rich targets. These detectors can be made inherently insensitive to electron recoils, while additional background suppression is achieved with the acoustic signature of the bubble nucleation that allows the identification of alpha particles. In this talk I will present recent results obtained with the PICO bubble chambers that operated at SNOLAB, including the latest results of the PICO-60 detector that set the most stringent constraints on the WIMP-proton spin-dependent coupling. I will also present on the current status of the PICO Collaboration's commissioning at SNOLAB of a 40-liter bubble chamber with a novel design, and on the progress of PICO-500, the next generation ton-scale PICO bubble chamber.

Session 5 / **98**

Probing Dark Matter Throughout Cosmic History

Author: Vera Gluscevic[1]

[1] *USC*

Corresponding Author: vera.gluscevic@usc.edu

I will review the status of cosmological searches for dark matter interactions, summarizing the best current limits on scattering of light particle candidates with protons derived from the cosmic-microwave-background anisotropy measurements. I will then present stringent new bounds on the same physics, inferred recently from the observed population of the Milky Way satellite galaxies. I will highlight complementarities between different observations and laboratory searches for dark matter, and discuss the prospects for unveiling the physics of dark matter in the coming decade.

Session 10 / **129**

Effective theory of nuclear scattering for WIMPs of arbitrary spin

Author: Paolo Gondolo[1]

[1] *University of Utah*

Corresponding Author: paolo.gondolo@utah.edu

We have extended the nonrelativistic effective theory of WIMP-nucleus scattering from WIMPs of spin 0, 1/2, and 1 to WIMPs of arbitrary spin, under the assumption of one-nucleon operators. New

effective operators arise at each additional half-unit of WIMP spin. The nuclear structure functions are the same for WIMPs of all spin. The theory can easily include mediators of any mass, and form factors for WIMPs of finite size. This talk will present the new operators and how they are constructed, together with some preliminary phenomenological results.

Session 6 / **25**

Sterile neutrino mass and mixing from cosmology and laboratory searches

Author: Steffen Hagstotz[1]

[1] *Stockholm University*

Corresponding Author: steffen.hagstotz@fysik.su.se

In my talk, I will present new constraints on sterile neutrino mixing parameters obtained from both cosmological and direct measurements. For the first time, we model the sterile in a full 3+1 framework coupled to all other neutrino flavours and consistently calculate the cosmological perturbations. CMB data dominates the resulting constraints on mass splitting and the mixing matrix elements. In addition, we translate the cosmological bounds to the parameters directly probed by laboratory searches, m_β and $m_{\beta\beta}$, and set independent competitive limits.
We also find that various hints of eV-scale sterile neutrinos from short-baseline experiments are in strong tension with cosmological constraints.

Session 9 / **139**

The HUNTER Sterile Neutrino Search Experiment

Authors: Andrew Lee Renshaw[1]; Christian Schneider[2]; Eric Hudson[2]; Jeff Martoff[3]; Paul Hamilton[2]; Peter Meyers[4]; Peter Smith[2]

[1] *University of Houston (US)*

[2] *UCLA*

[3] *Temple University*

[4] *Princeton University*

Corresponding Author: paul.hamilton@ucla.edu

The HUNTER experiment (Heavy Unseen Neutrinos from Total Energy-Momentum) is a laboratory-based search for sterile neutrinos with sensitivity to the 20-280 keV mass range. The sterile neutrino mass will be reconstructed through precise measurement of the energy and momentum of the products in an electron capture decay of 131-Cs to determine the “missing” mass. Two reaction-microscope spectrometers using spatially resolved time-of-flight measurements will reconstruct the charged product kinematics after an x-ray trigger from LYSO scintillators read out by silicon photomultiplier arrays. The experiment requires a low temperature, high efficiency source of 131-Cs atoms, uniform ion extraction electric and electron confinement magnetic fields, a large solid angle for x-ray detection, and precision in-situ alignment. I will discuss our innovative solutions to meet these requirements and give an update on the apparatus development.

- Financial support by the W. M. Keck Foundation and our respective universities is gratefully acknowledged.

Session 10 / **16**

Prospects for DM Direct Detection in (non-)SUSY models

Author: Sven Heinemeyer[1]

[1] *CSIC (Madrid, ES)*

Corresponding Author: sven.heinemeyer@cern.ch

We perform global fits on various SUSY models as well as on simplified DM models with leptophobic/philic mediators. These fits take into account astrophysical data (relic abundance and DD limits), searches at the LHC as well as other measurements (Higgs, low-energy and flavor observables). Based on these fits we predict the favored ranges for DM masses and Direct Detection cross sections. In particular, in the simplified model approach we go beyond the analyses done by the LHC DM WG and perform a fit to the full available parameter space.

Session 8 / **103**

The Light Dark Matter eXperiment, LDMX

Author: David Hitlin[1]

[1] *Caltech*

Corresponding Author: hitlin@caltech.edu

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.

Session 9 / **15**

TRISTAN: a novel detector for keV sterile neutrino search with KATRIN

Author: Thibaut Houdy[1]

Co-author: Susanne Mertens [2]

[1] *Max Planck Institute for Physics, Munich*

[2] *Max Planck Institute for Physics*

Corresponding Author: thoudy@mppmu.mpg.de

The KATRIN (Karlsruhe Tritium Neutrino) experiment investigates the energetic endpoint of the tritium beta-decay spectrum to determine the effective mass of the electron anti-neutrino. The collaboration reported its first result in fall 2019, publishing the best limit up-to-date on neutrino mass from direct measurement.

The TRISTAN project aims at detecting a keV-sterile neutrino signature by measuring the entire tritium beta-decay spectrum with an upgraded KATRIN system. One of the greatest challenges is to handle the high signal rates generated by the strong activity of the KATRIN tritium source while keeping a good energy resolution. Therefore, a novel multi-pixels silicon drift detector and read-out are being designed to handle rates up to 100 Mcps with an energy resolution of 200 eV (FWHM) at 10 keV.

This talk will present the first KATRIN results and future perspectives to search for sterile neutrinos with KATRIN.

Session 5 / **46**

Dark Matter Interpretation of the Fermi-LAT Observations Toward the Outer Halo of M31

Author: Chris Karwin[1]

Co-authors: Simona Murgia [2]; Igor Moskalenko [3]; Adam Green [2]; Daniel McKeown [2]; Francisco Mercado [2]; Sean Fillingham [4]; Philip Tanedo [5]; James Bullock [2]

[1] *Clemson University*

[2] *University of California, Irvine*

[3] *Stanford University*

[4] *University of Washington*

[5] *University of California, Riverside*

Corresponding Author: ckarwin@clemson.edu

An excess γ-ray signal toward the outer halo of M31 has recently been reported. Although other explanations are plausible, the possibility that it arises from dark matter (DM) is valid. In this talk I will first briefly review the Fermi-LAT observations toward the outer halo of M31. I will then present results for a DM interpretation of the observed excess. We use as our representative case WIMP DM annihilating to bottom quarks, and we make a detailed study of the systematic uncertainty in the J-factor for the M31 field. We find that the signal favors a DM particle with a mass of $\sim$50$-$90 GeV. The full systematic uncertainty in the cross-section currently spans roughly three orders of magnitude, ranging from $\sim 4 \times 10^{-27} - 4 \times 10^{-24}$ cm^3 s^{-1}. This high uncertainty is due to two main factors, namely, an uncertainty in the substructure nature of M31's DM halo, as well as an uncertainty in the contribution to the signal from the Milky Way's DM halo along the line of sight. However, apart from the extreme ends in the uncertainty, we show that the median uncertainty range has a large overlap with the DM interpretations of both the Galactic center (GC) excess and the antiproton excess. More generally, we summarize the current state of DM indirect detection in the energy range 10 GeV - 300 GeV corresponding to the GC excess and identify a region in parameter space that still remains viable for discovery of the DM particle.

Session 13 / **55**

The Design and Construction of the LUX-ZEPLIN (LZ) Experiment

Author: Dev Ashish Khaitan[1]

[1] *University of Rochester*

Corresponding Author: dkhaitan@pas.rochester.edu

LUX-ZEPLIN (LZ) is a direct detection dark matter experiment, currently under construction 4850ft underground at the Sanford Underground Research Facility in Lead, SD, USA. At the core of the LZ design is a dual-phase liquid Xe time projection chamber (TPC) with a 7 ton active mass. This experiment will achieve a sensitivity of 1.6×10^{-48} cm^2 to 40 GeV/c^2 WIMPs in a 1000 day exposure. To achieve the backgrounds necessary for this experiment a rigorous radioassay, radon emanation, and cleanliness programs were employed and an active veto detector is built around the TPC. This presentation gives an overview of the LZ experiment, its design goals and construction status.

Session 17 / **20**

Hunting Axion Dark Matter with MADMAX (MAgnetized Disk and Mirror Axion eXperiment)

Author: Stefan Knirck[1]

[1] *Max-Planck-Institute for Physics, Munich, Germany*

Corresponding Author: knirck@mpp.mpg.de

The QCD axion is an excellent light dark matter candidate, while also naturally explaining CP-conservation in strong interactions. Axions generated after inflation are expected to have masses around 100μeV, which is at present inaccessible by existing cavity searches.
Galactic axions can be converted to electromagnetic radiation at boundaries between different dielectric constants under a strong magnetic field. Combining many such surfaces, this conversion can be enhanced significantly using constructive interference and resonances.
The proposed MADMAX setup containing around 80 dielectric disks and a mirror in a $\sim 10\,\mathrm{T}$ magnetic field could probe the QCD axion in the well-motivated mass range of $40 - 400\,\mu\mathrm{eV}$.
The experimental idea, the proposed design and expected sensitivity will be presented. Recent R&D results from 3D simulations and proof of principle prototype measurements and future plans are discussed.

Session 1 / **69**

Dark Energy in 2020

Author: Elisabeth Krause[1]

[1] *The University of Arizona*

Corresponding Author: krausee@email.arizona.edu

Twenty years after the discovery of cosmic acceleration, or Dark Energy, there is now robust evidence from a number of independent precision measurements. I will review recent progress on determining the properties of Dark Energy from different cosmological probes, highlight growing tensions in the LCDM paradigm, and conclude with an outlook on upcoming large experiments of the early 2020s.

Session 12 / **48**

Status of the PICO-40L Experiment

Author: Carsten Krauss[1]

[1] *University of Alberta*

Corresponding Author: carsten@ualberta.ca

PICO-40L is the most advanced bubble chamber using about 50kg of a fluorine rich target material. The detector has a new chamber concept without buffer fluid, eliminating the backgrounds associated with the water in contact with the active liquid in previous PICO bubble chambers. We will report the status of the commissioning and give a first indication of the background rates in the chamber.

Session 7 / **77**

Discovering Dark Matter with Ionization: DM-Electron Scattering versus the Migdal Effect

Author: Gordan Krnjaic[1]

[1] *Fermilab*

Corresponding Author: krnjaicg@fnal.gov

There are currently several existing and proposed experiments designed to probe sub-GeV dark matter (DM) using electron ionization in various materials. The projected signal rates for these experiments assume that this ionization yield arises only from DM scattering directly off electron targets, ignoring secondary ionization contributions from DM scattering off nuclear targets. In this work we investigate the validity of this assumption and show that if sub-GeV DM couples with comparable strength to both protons and electrons, as would be the case for a dark photon mediator, the ionization signal from atomic scattering via the Migdal effect scales with $^{2}(/)^{22}$ where is the mass of the target nucleus and is the 3-momentum transferred to the atom. The result is that the Migdal effect is always subdominant to electron scattering when the mediator is light, but that Migdal-induced ionization can dominate over electron scattering for heavy mediators and DM masses in the hundreds of MeV range. We put these two ionization processes on identical theoretical footing, address some theoretical uncertainties in the choice of atomic wavefunctions used to compute rates, and discuss the implications for DM scenarios where the Migdal process dominates, including for XENON10, XENON100, and the recent XENON1T results on light DM scattering.

Session 8 / **74**

Search for new particles with the FASER Experiment

Author: Susanne Kuehn[1]

[1] *CERN*

Corresponding Author: susanne.kuehn@cern.ch

The FASER, ForwArd Search ExpeRiment is an experiment under construction at the Large Hadron Collider at CERN, Switzerland. It's aim is to be operational at the next run of the LHC from 2021 and search for new light and weakly-interacting particles. At high-energy colliders, they may be produced at low transverse momentum and highly collimated in the very forward direction of the

collision points of the e.g. proton beams at the LHC. Therefore the experiment is being built at about 480 m downstream of the interaction point of one of the general-purpose experiments and along the beam axis. It is consisting of magnets, a scintillator system, a calorimeter and tracker with several silicon detector layers.
In the presentation, the sensitivity of the experiment will be presented for several benchmark models, namely for dark photons, the dark higgs and axion-like particles. Moreover, the detector layout and components will be described. Details will be given on the status of construction on surface and in the tunnel and latest results of measurements during commissioning of the detector components.

Session 10 / **65**

Dynamics of millicharged dark matter in supernova remnants

Author: Jung-Tsung Li[1]

[1] *UC San Diego*

Corresponding Author: lijungtsung@gmail.com

Millicharged dark matter (mDM) would form a plasma and interact with the interstellar medium and electromagnetic fields within galaxies. In this presentation, I will show a microphysical model where mDM is shocked by a supernova remnant and isotropized in the frame of the expanding fluid. We find that for $|q_\chi/m_\chi| > 10^{-13}e/\mathrm{MeV}$, the isotropization length for electromagnetic plasma instabilities is much shorter than the size of the supernova remnant. This is a necessary, though not sufficient, first step for formation of a Fermi-accelerated dark cosmic ray. I will discuss additional implications of mDM interactions in supernova remnants.

Session 13 / **88**

Scintillation yield from electronic and nuclear recoils in superfluid helium-4

Authors: Junsong Lin[1]; Ethan Bernard[2]; Madeline Bernstein[2]; Andreas Biekert[2]; Scott Hertel[None]; Scott Kravitz[3]; Daniel Mckinsey[None]; Pratyush Patel[4]; Harold Pinckney[5]; Roger Romani[2]; Alessandro Serafin[6]; Ryan Smith[2]; Burkhant Suerfu[2]; Vetri Velan[2]; Lanqing Yuan[2]

[1] *University of California Berkeley*

[2] *University of California, Berkeley*

[3] *Lawrence Berkeley National Laboratory*

[4] *University of Massachusetts Amherst*

[5] *University of Massachusetts at Amherst*

[6] *University of Massachusetts*

Corresponding Author: junsonglin@berkeley.edu

Superfluid He-4 is a promising target material for direct detection of light (< 1 GeV) dark matter. Signal channels for dark matter - nucleus interactions in superfluid helium include prompt photons, triplet excimers, rotons and phonons, but measurement of these signal strengths have yet to be performed for low energy nuclear recoils. A measurement of the prompt scintillation yield from electronic and nuclear recoils was carried out in superfluid He-4 at ˜1.75 Kelvin, with deposited energy in the range of 10-1000 keV. The scintillation from a 16 cubic cm volume of superfluid He-4, with tetraphenyl butadiene as wavelength shifter deposited on 1-mm thick quartz panels, was read out by six R8520-06 MOD PMTs immersed in the superfluid, each individually biased by a Cockcroft-Walton

generator. Elastic scattering of 2.8 MeV neutrons (generated by a deuterium-deuterium neutron generator) from superfluid He-4, with a liquid organic scintillator module used as far-side detector, was used to determine the scintillation signal yield for a variety of nuclear recoil energies. For comparison, Compton scattering of Cs-137 gamma-rays with the superfluid He-4, with NaI scintillators used as far-side detectors, was used to determine the scintillation signal yield of electronic recoils.

Session 14 / **42**

HydroX: Hydrogen in Xenon to search for light dark matter particles

Author: Hugh Lippincott[1]

[1] *Fermilab*

Corresponding Author: hugh@fnal.gov

Large mass liquid xenon detectors, such as LUX-ZEPLIN (LZ) and XENONnT, are leading the search for dark matter particles with masses above ˜5 GeV/cˆ2, with both spin-dependent and spin-independent couplings. HydroX is a new effort to dissolve hydrogen into liquid xenon to allow these experiments to probe sub-GeV/cˆ2 dark matter. The use of hydrogen-doped xenon takes advantage of the kinematic matching of the light nucleus to dark matter particles with masses down to ˜100 MeV, while retaining the excellent self-shielding property of liquid xenon. This talk will give an overview of the use of dissolved hydrogen in liquid xenon for sub-GeV/cˆ2 dark matter searches and describe ongoing and planned R&D efforts for HydroX.

RECEPTION and POSTER SESSION IN THE SAME ROOM / **90**

DMFlux: a tool for neutrino flux generation from dark matter annihilation and decay

Author: QINRUI LIU[1]

Co-author: Francis Halzen [2]

[1] *University of Wisconsin-Madison*

[2] *University of Wisconsin*

Corresponding Author: qliu246@wisc.edu

Among messengers used in indirect searches for dark matter (DM), neutrinos are special as they are neutral, light, and seldom interact. These unique properties give them advantages in astrophysical studies: they are advantageous over cosmic rays as they are able to point back to their sources and unlike gamma rays can exit environments of large matter and radiation densities. I will present a new flexible Monte Carlo simulation tool to generate neutrino fluxes at detectors searching for signatures of DM annihilation and decay. The expected flux from galactic and extragalactic sources will be discussed, as well as the Earth and the Sun. In the latter case, we will also consider the possibility of a secluded dark matter sector which introduces a long-lived mediator.

Session 12 / **75**

New physics searches with MAJORANA DEMONSTRATOR

Author: Mariano Lopez[None]

Corresponding Author: mariano.lopez@enpa.physics.unc.edu

The MAJORANA DEMONSTRATOR is an ultra-low background experiment operating on the 4850' ulevel of the Sandford Underground Research Facility in South Dakota, which operates an array of p-type point contact (PPC) high-purity germanium (HPGe) detectors made of both natural materials as well as materials enriched in ^{76}Ge. The surface exposure time of MAJORANA enriched detectors was minimized to reduce cosmogenic activation and backgrounds at low energy. The experiment has been collecting data since 2015 and the analysis energy threshold has been established on the order of a keV, which allows a wide range of rare event searches, such as bosonic dark matter, solar axions and lightly ionizing particles, to probe new physics beyond the Standard Model. Recent efforts to filter the electronic noise and to understand the observed backgrounds at those energies, along with accumulated larger datasets, have made it possible to set tighter limits on several of these rare event searches. To improve those limits, new methods to assess the efficiency of selecting physics events have also been developed. In this talk, I will present the current status, new analysis methods, and the latest results of the MAJORANA low energy program.

RECEPTION and POSTER SESSION IN THE SAME ROOM / 122

Sterile neutrinos in non-standard pre-BBN cosmologies

Corresponding Author: philiplu11@gmail.com

Session 12 / 11

Testing DAMA/LIBRA signal: ANAIS-112 two years result

Authors: Alfonso Ortiz[1]; Ana Salinas[1]; David Cintas[1]; Eduardo Garcia[1]; Ivan Coarasa[1]; Jorge Puimedon[1]; Julio Amare[1]; Miguel Angel Olivan[1]; Patricia villar[1]; Susana Cebrian[1]; Ysrael Ortigoza[1]

[1] *University of Zaragoza*

Corresponding Author: mariam@unizar.es

ANAIS (annual modulation with NaI Scintillators) is a dark matter direct detection experiment located at the Canfranc Underground Laboratory (LSC, Spain).
Its main goal is to test in a model independent way the DAMA/LIBRA positive result: an annual modulation in the low-energy detection rate compatible with the expected signal induced by WIMPs in the galactic halo.
ANAIS-112, consisting of 112.5 kg of NaI(Tl) scintillators, was installed at the LSC in August 2017. In this talk I will present the performance of the detector and preliminary results corresponding to 2 years of data. These results are compatible with the absence of modulation and in some tension with DAMA/LIBRA result. Moreover, they support our goal of reaching a 3σ sensitivity to the DAMA/LIBRA result with about 5 years of data.

Session 12 / 134

Status of the DAMIC-M Dark Matter Search Experiment

Author: PITAM MITRA[1]

[1] *University of Washington*

Corresponding Author: pitamm@uw.edu

DAMIC-M is a next-generation experiment to search for dark matter with charge coupled devices (CCDs) in the Modane Underground Laboratory in France. It builds on the success of DAMIC at SNOLAB, which pioneered the detection of nuclear and electronic recoils in the bulk silicon of CCDs deployed in a low-background environment. The dominant source of noise in conventional CCDs lie in their readout stage. A modification in the design of this stage makes it possible to measure the ionization charge collected per pixel many times over. Such "skipper" CCDs can resolve individual electrons per pixel, which allows for sensitivity to a few eV of energy deposited in the target. DAMIC-M will feature a tower of fifty of the most massive CCDs ever built with the skipper readout. It will achieve an improvement of several orders of magnitude in the exploration of the dark matter particle hypothesis, in particular of candidates pertaining to the so-called "hidden sector."In this talk I will summarize the progress toward the DAMIC-M experiment.

Session 15 / **101**

Physics reach of the LUX-Zeplin Dark Matter Experiment

Author: Maria Elena Monzani[1]

[1] *SLAC*

Corresponding Author: monzani@slac.stanford.edu

The nature and origin of Dark Matter are among the most compelling mysteries of contemporary science. For over three decades, physicists have been trying to detect Dark Matter particles via collisions on target nuclei, with little success.
The LZ collaboration is building a massive Dark Matter detector, which is currently being installed at the 4850 level of the Sanford Underground Research Facility in Lead, South Dakota. This detector features 7 active tons of target nuclei and uses the established liquid xenon TPC technology to achieve unprecedented sensitivity to a wide range of Dark Matter candidates. In this talk I will review the physics reach of the LZ experiment.

Session 2 / **127**

Search for dark matter with IACTs and the Cherenkov Telescope Array Aldo Morselli for the CTA Consortium

Corresponding Author: aldo.morselli@roma2.infn.it

In the last decades an incredible amount of evidence for the existence of dark matter has been accumulating. At the same time, many efforts have been undertaken to try to identify what dark matter is.
Indirect searches look at places in the Universe where dark matter is known to be abundant and seek for possible annihilation or decay signatures. Indirect searches with the Fermi Gamma-ray Space Telescope and Imaging Atmospheric Cherenkov Telescopes (IACTs) are playing a crucial role in constraining the nature of the DM particle through the study of their annihilation into gamma rays from different astrophysical structures. In this talk I will review
the status of the search with IACTs and I will describe the sensitivity projections for dark matter searches on the various targets taking into account the latest instrument response functions expected for the Cherenkov Telescope Array (CTA) together with estimations for the systematic uncertainties from diffuse astrophysical and cosmic-ray backgrounds.

Session 9 / **104**

Miraculous and Varied Production of Sterile Neutrino Dark Matter, Structure Formation and X-ray Lines

Author: Kevork N. Abazajian[None]

Corresponding Author: kevork@uci.edu

I will review the variety of dark matter production models for sterile neutrino dark matter and their connection to structure formation and X-ray line detection, including the candidate 3.5 keV line. Structure formation continues to constrain dark matter to be increasingly cold, yet puzzles remain in galactic substructure. A few searches have claimed constraints on the presence of a dark matter source for the 3.5 keV line, yet the 3.5 keV continues been seen in a large number of sources on the sky. New technologies must come on line for a definitive experimental result.

Session 6 / **8**

Milky Way Satellites: Probes of Dark Matter Microphysics

Author: ethan nadler[1]

[1] *Stanford University*

Corresponding Author: enadler@stanford.edu

As luminous tracers of the smallest observationally accessible dark matter halos, faint satellite galaxies orbiting the Milky Way (MW) have the potential to dramatically improve our understanding of dark matter microphysics. However, the confounding effects of baryonic physics on halo abundances and galaxy formation have made the interpretation of the observed MW satellite population unclear. I will describe a forward model for the MW satellite population based on high-resolution zoom-in simulations that marginalizes over these astrophysical effects and accounts for the relevant numerical and observational uncertainties. Combined with newly derived observational selection functions and detailed modeling of the satellite population associated with the Large Magellanic Cloud, this method yields constraints on a variety of dark matter models including sterile neutrinos, ultra-light axions, and interacting dark matter that are competitive with Lyman-alpha forest and strong gravitational lensing measurements. I will highlight limits on the DM-baryon scattering cross section in WIMP-like scenarios that improve upon CMB and Lyman-alpha forest analyses by several orders of magnitude.

Session 13 / **67**

Novel Charge Readouts for a CYGNUS-10 Directional Detector at Boulby

Author: Spooner Neil[1]

[1] *University of Sheffield*

Corresponding Author: n.spooner@sheffield.ac.uk

The CYGNUS collaboration is developing a range of approaches towards a global dark matter experiment in the form of an array of nuclear recoil direction sensitive detectors, distributed at multiple underground sites. Here we describe demonstration of two new hybrid TPC charge readout concepts for CYGNUS, capable of use with SF6 negative ion gas. The first comprises a thick GEM gain stage coupled to a multi-wire plane with 600 micron position resolution. The second combines a micromegas strip readout with a new form of gain stage specifically designed for SF6 operation.

This is a hybrid GEM geometry that incorporates multiple internal meshes within the GEM holes to provide two separate internal gain stages. Performance characteristics are presented, including data on ionisation track reconstruction, and implications discussed for development of a CYGNUS-10 experiment at the Boulby underground site.

Session 1 / **26**

A Review of strong gravitational lensing constraints on the nature of dark matter

Author: Anna Nierenberg[None]

Corresponding Author: amn3142@gmail.com

Strong gravitational lensing provides a powerful probe of the nature of dark matter as it is sensitive to the presence of low mass structure regardless of whether that structure contains stars or gas. I will present a review of strong gravitational lensing dark matter measurements, and discuss future paths for these methods.

Session 15 / **86**

DarkSide-20k Design and Physics Prospects

Authors: TBD[None]; DarkSide Collaboration[None]

Corresponding Author: pantic@ucdavis.edu

DarkSide-20k, is designed as a 20-tonne fiducial mass Time Projection Chamber with SiPM based photosensors, expected to be free of any instrumental background for an exposure of >100 ton x years.
The dual phase TPC will use a total of 50 t low radioactivity Argon from underground source and will be realized within a sealed acrylic vessel surrounded by an active neutron veto detector. The latter is composed of a Gd-loaded acrylic shell immersed in an atmospheric liquid argon bath contained in a ProtoDune-like membrane cryostat.
Like its predecessor DarkSide-20k will be housed at the Gran Sasso (LNGS) underground laboratory, and it is expected to attain a WIMP-nucleon cross section exclusion sensitivity of $10^{-47}\,cm^2$ for a WIMP mass of $1TeV/c^2$ in a 5 yr run.
A subsequent objective, towards the end of the next decade, will be the construction of the ultimate detector, ARGO, with a 300 t fiducial mass to push the sensitivity to the neutrino floor region for high mass WIMPs.

Session 9 / **56**

Leading Sensitivity to Sterile Neutrino Dark Matter with NuSTAR

Authors: Kerstin Perez[1]; Brandon Roach[2]; Kenny Chun Yu Ng[3]; John Beacom[4]; Shunsaku Horiuchi[5]; Roman Krivonos[6]; Daniel Wik[7]

[1] *MIT*

[2] *Massachusetts Institute of Technology*

[3] *Weizmann Institute of Science*

[4] *Ohio State University*

[5] *Virginia Tech*

[6] *IKI*

[7] *University of Utah*

Corresponding Author: kmperez@mit.edu

Sterile neutrinos, which could provide an elegant solution to the puzzle of the observed active neutrino masses and mixing, are among the most well-motivated dark matter candidates, with astrophysical X-ray observations offering the best opportunity for discovery. The NuSTAR X-ray observatory' s broad energy range and wide-angle aperture for unfocused photons has allowed for leading sensitivity to sterile neutrinos over the mass range ˜10-50 keV. In this talk, I will detail how NuSTAR observations of the Galactic center, Galactic bulge, M31, and extragalactic fields have improved upon previous limits at some masses by over an order of magnitude. Future sensitivity using NuSTAR, in particular for photon energies <5 keV (masses <10 keV), is now limited by understanding of instrumental background effects. I will conclude with a roadmap toward optimizing NuSTAR searches across the mass range ˜6-50 keV.

Session 11 / **95**

In Search of Cosmic-Ray Antinuclei from Dark Matter with the GAPS Experiment

Author: Kerstin Perez[1]

[1] *MIT*

Corresponding Author: kmperez@mit.edu

The GAPS Antarctic balloon payload, scheduled for its initial flight in late 2021, is the first experiment optimized specifically for low-energy cosmic antinuclei signatures of dark matter. Low-energy antideuterons provide a "smoking gun" signature of dark matter annihilation or decay, essentially free of astrophysical background. Studies in recent years have emphasized that models for cosmic-ray antideuterons must be considered together with the abundant cosmic antiprotons and any potential observation of antihelium. Together, these signatures offer a potential breakthrough in unexplored dark matter parameter space, providing complementary coverage with direct detection, collider, and other indirect searches. In this contribution, I will detail the novel GAPS detection technique, based on exotic atom capture and decay; the status of the GAPS instrument construction; and the potential of upcoming measurements to clarify ongoing open issues.

RECEPTION and POSTER SESSION IN THE SAME ROOM / **54**

Multiscatter Capture of Intermediate Mass Dark Matter by Population III Stars

Author: Jacob Pilawa[1]

Co-author: Cosmin Ilie [1]

[1] *Colgate University*

Corresponding Author: jpilawa@colgate.edu

Self-annihilating dark matter, captured in the gravitational field of stars or other compact objects, can produce detectable fluxes and impact the evolution and observability of Population III stars. In the regime between WIMP dark matter masses (10^2 GeV) and superheavy masses ($> 10^8$ GeV), the number of scattering events required for capture increases from of order unity to thousands of scatters. Using the analytic formalism of multi scatter capture, combined with the latest constraints

on dark matter cross section and Pop. III stellar evolution simulations, we calculate upper bounds on the capture rates of dark matter inside Pop. III stars. Assuming that a non-zero fraction of the capture dark matter thermalizes inside the star, we find that the additional heating from self-annihilating dark matter can become significant. Requiring that these stars shine at sub-Eddington luminosities, we impose upper bounds on the masses and luminosities on the first stars at the Epoch of Reionization, opening up the possibility of constraining dark matter properties using the initial mass function of extremely metal-poor stars.

Session 8 / **33**

The Scientific Program of the PADME experiment

Author: Paola Gianotti[None]

Corresponding Author: gabriele.piperno@roma1.infn.it

Massive photon-like particles are predicted in many extensions of the Standard Model as possible portals toward a hidden sector where Dark Matter is secluded [1]. They are vector bosons mediating the interaction between ordinary and dark matter and can be produced in different processes through a feeble mixing to the photon. The PADME experiment [2], conducted at Laboratori Nazionali di Frascati of INFN, searches for a signal of a Dark Photon A'in the e+e−⟶γA'reaction in a positron-on-target experiment. For this purpose, the missing mass spectrum of annihilation final states with a single photon is analyzed. In about one year of data taking, a sensitivity on the interaction strength down to 0.001 is achievable in the mass region M(A') <23.7 MeV.
In addition, the PADME approach allows searches for any new particle produced in e+e− collisions through a virtual off-shell photon, such as long lived Axion-Like-Particles (ALPs), proto-phobic X bosons, Dark Higgs, etc. In the talk, the scientific program of the experiment and its current status will be illustrated.

References
[1] B. Holdom, Phys. Lett B 166, 196 (1986).
[2] V. Kozuharov and M. Raggi, Adv. High Energy Phys. 2014, 959802 (2014).

Session 10 / **12**

The QCD Axion and Unification

Authors: Alexis Plascencia[1]; Pavel Fileviez Perez[1]; Clara Murgui[None]

[1] *Case Western Reserve University*

Corresponding Author: alexis.plascencia@case.edu

The QCD axion is one of the most appealing candidates for the dark matter in the Universe. In this talk, I will discuss the possibility to predict the axion mass in the context of renormalizable grand unified theories where the Peccei-Quinn scale is determined by the unification scale. In the minimal theory with the KSVZ mechanism the axion mass is predicted to be in the range m = (3 - 13) neV. In addition, the minimal theory with the DFSZ mechanism predicts the axion mass to be m = (2 - 16) neV. I will also discuss the axion phenomenology and argue that the ABRACADABRA and CASPEr-Electric experiments will be able to fully probe these predictions.

Session 5 / **23**

Visibility-space Bayesian forward modeling of radio interferometric gravitational lens observations

Author: Devon Powell[1]

[1] *Max Planck Instute for Astrophysics*

Corresponding Author: dmpowell@mpa-garching.mpg.de

Gravitational lensing by galactic potentials is a powerful tool with which to probe the abundance of low-mass dark matter structures in the universe. Dark matter substructures or line-of-sight haloes introduce small scale perturbations to the smooth lensing potential. By observing detections (or non-detections) of such low-mass perturbers in lensed systems, we can place constraints on the halo mass function and differentiate between different particle models for dark matter.

The lowest detectable perturber mass is related to the angular resolution of the observation via its Einstein radius. Therefore, high angular resolution observations can place the strongest constraints on the low end of the halo mass function. In this talk, I will discuss the development of a fully Bayesian gravitational lens modeling code that directly fits large radio interferometric datasets from the Global Very Long Baseline Interferometry array (GVLBI). While the angular resolution is excellent (sufficient to detect haloes down to 10ˆ6 solar masses at zˆ0.5-1.0), these data contain large numbers (>10ˆ9) of visibilities and therefore present unique computational challenges for modeling.

I will present the computational methods developed for this modeling process, as well as results from GVLBI observations of the lensed radio jet MG J0751+2716.

RECEPTION and POSTER SESSION IN THE SAME ROOM / 140

GAPS TOF: towards construction of a large area, fast, and light weight balloon-borne time of flight system

Author: Sean Quinn[1]

[1] *UCLA*

Corresponding Author: spq@g.ucla.edu

The TOF is comprised of an outer "umbrella" and nearly hermetic inner "cube" giving a combined total surface area of ~ 53 m^2. Counters will be mounted to the balloon gondola using a novel carbon fiber structure. Each counter end will be read out using a silicon photomultiplier (SiPM) based analog front end. A high gain timing channel is sampled and digitized, while the low gain output is used for triggering. A central board processes all trigger inputs and will initiate a TOF and tracker read out based on interesting hit patterns. Beyond serving as the instrument trigger, the TOF will measure primary β and charge Z. Here we report on hardware advances made over the past several months, current system performance, early testing results, and construction plans of the TOF system leading up to the launch of GAPS.

Session 12 / 100

Progress on Dark Matter search with ArDM at Canfranc

Author: Balint Radics[1]

[1] *CERN*

Corresponding Author: balint.radics@cern.ch

The ArDM experiment, a tonne-scale dual-phase liquid Argon TPC, has recently finished data taking in dual-phase mode. Earlier data taken in single-phase mode enabled us to reach a full understanding of all the instrumental and external background sources in the experiment. Recent data taken in dual-phase mode allows a further improvement of the experiment. In this talk the status of the analysis of the dual-phase data is presented.

Session 3 / **120**

Axions: Phenomenology and Detection

Corresponding Author: srajend4@jhu.edu

Axions generically emerge in many contexts of particle physics. They may also solve long standing theoretical problems such as the strong CP, gauge hierarchy and the cosmological constant problems. In this talk, I will briefly discuss these theoretical ideas and focus on new experimental methods to find these particles

Session 13 / **130**

The LUX experiment: review of the recent data analysis progress

Author: Quentin Riffard[1]

[1] *Lawrence Berkeley National Laboratory*

Corresponding Author: qriffard@lbl.gov

The LUX collaboration has pioneered new techniques in the quest of solving the dark matter puzzle. Using liquid xenon (LXe) dual-phase TPC technologies,
the collaboration set several world leading limits on WIMP dark matter. Even after the detector decommissioning in 2016 the analysis work continues. In this presentation, I will give an overview of the recent results published by the LUX collaboration, including: the sub-GeV Dark Matter search, the improvement of the electron recoil detector response model for LXe and the searches applying an effective field theory approach. I will also present some preliminary results of on-going analyses about future detector performance and the re-analysis of the background after the detector decommissioning.

Session 13 / **94**

Light detection in DarkSide-20k

Author: Luigi Pio Rignanese[1]

[1] *Universita e INFN, Bologna (IT)*

Corresponding Author: luigi.pio.rignanese@cern.ch

The DarkSide multi-stage program aims to search for WIMPs by building and operating a dual phase liquid Argon (LAr) time projection chamber (TPC). The upcoming DarkSide-20k detector, with a fiducial mass of 20 tonnes of depleted liquid Argon, will operate in the underground laboratories of "Lab-

oratori Nazionali del Gran Sasso". The photodetection relies on Silicon photomultipliers (SiPMs). Compared to photomultipliers (PMTs), this new type of detector has higher single-photon resolution and photodetection efficiency, resulting in an increased experiment sensitivity. The DarkSide-20k TPC will be instrumented with 8280 photodetection modules (PDMs). Each of them has an area of about $25cm^2$ and consists of a $6X4$ matrix of SiPMs developed in collaboration with FBK. All the SiPMs are read out as a single channel thanks to a custom cryogenic readout electronic system. This talk will focus on the PDM design and the photo-sensor performance in term of dark count rate (DCR), SNR and time resolution. In addition, the signal extraction technique, which is based on analog optical signaling, will be discussed.

Session 13 / **41**

Background Modeling in the LUX Detector for an Effective Field Theory Dark Matter Search

Author: Gregory Rischbieter[None]

Corresponding Author: g.rc.rischbi@gmail.com

Historically, dark matter direct detection experiments searching for dark matter in the form of Weakly Interacting Massive Particles (WIMPs) typically consider only two couplings between atomic nuclei and the WIMP: spin-independent and spin-dependent interactions. However, the lack of of an observed WIMP signal encourages consideration of more WIMP-nucleon interaction types, and recent theoretical work provides a basis composed of 14 independent effective field theory (EFT) operators. The inclusion of these additional operators leads to the possibility of WIMP interactions at higher energies than traditional WIMP analyses. In this presentation we will report on the search for WIMP-nucleon interactions at higher energies with data collected by the LUX detector during its tenure in the Davis Campus of the Sanford Underground Research Facility. Specifically, we will discuss background modeling for an EFT dark matter search, and we will present the results of the EFT analyses using LUX data.

Session 2 / **118**

Dark matter searches with neutrino telescopes

Corresponding Author: carsten.rott@gmail.com

Session 4 / **111**

Direct detection without noble gases

Corresponding Author: sadoulet@berkeley.edu

Session 7 / **57**

WIMP dark matter from a nu perspective

Author: IBRAHIM SAFA[1]

Co-authors: Carlos Arguelles [2]; Alejandro Diaz [3]; Ali Kheirandish ; Aaron Vincent [4]; Andres Olivares [5]

[1] *University of Wisconsin - Madison*

[2] *MIT*

[3] *Massachusetts Institute of Technology*

[4] *Queen's University*

[5] *IPPP, Durham University*

Corresponding Author: isafa@wisc.edu

We report on the status of WIMP dark matter by exploring the most invisible final state: neutrinos. We provide new model-independent limits on dark matter annihilation into neutrinos in a mass range spanning MeV to ZeV. Interestingly, our limits using the latest SuperK data are inching ever closer to the thermal relic cross section. We also show projections for the next generation of neutrino experiments and explore the region beyond EeV for the first time.

Session 2 / **63**

Dark matter in the Milky Way

Author: Robyn Sanderson[1]

[1] *University of Pennsylvania*

Corresponding Author: robynes@sas.upenn.edu

The results of the Gaia astrometric mission have ushered in a new era of "precision Galactic dynamics." Using this new phase-space map of Galactic stars with unprecedented volume, we are beginning to obtain new insights into the dark matter distribution in our Galaxy. Thanks to significant advances on the computational front, meanwhile, we can now compare these insights directly with, and test our modeling strategies on, simulations of Milky-Way-mass galaxies where the influence of baryons and the cosmological context on the dark matter structure are realistically taken into account. I will review recent advances in our understanding of the Milky Way's dark matter distribution, made possible by this convergence of new data and better models, and outline prospects for the near future.

Session 12 / **71**

Recent Results from XENON1T

Author: Evan Shockley[None]

Co-author: XENON Collaboration

Corresponding Author: ershockley@uchicago.edu

XENON1T is a tonne-scale liquid xenon time-projection chamber that operated from early 2016 through the end of 2018. With unprecedented low background levels and an energy threshold of about 1 keV (0.2 keV in ionization-only analyses), XENON1T is sensitive to a multitude of ultra-rare processes predicted by both Standard Model (SM) and Beyond-SM physics. In this talk I will discuss the most recent results from the XENON1T experiment, including rare-event searches in both the electron- and nuclear-recoil channels.

RECEPTION and POSTER SESSION IN THE SAME ROOM / **82**

The relation between Migdal effect and dark matter-electron scattering in isolated atoms and semiconductors

Author: Mukul Sholapurkar[None]

Co-authors: Rouven Essig ; Tien-Tien Yu ; Josef Pradler

Sub-GeV dark matter direct detection experiments can look for small ionization signals that arise from dark matter-electron scattering or from the Migdal effect in dark matter-nucleus scattering. In this talk, I will show that the theoretical description of both these processes is closely related, and that there is a parametric mapping between them. I will first consider the case of noble-liquid targets and will then show first estimates of the Migdal effect in semiconductors using a crystal form factor that takes the band structure into account. I will then present new dark matter-nucleus scattering limits using XENON10, XENON100, and SENSEI data, and give projections for proposed experiments. Finally, I will show a comparison of DM-electron scattering and the Migdal effect in the concrete case of the Dark Photon model.

Session 8 / **7**

Recent Searches for Hidden-Sector Particles with BABAR

Author: Brian Shuve[1]

[1] *Harvey Mudd College*

Corresponding Author: bshuve@g.hmc.edu

Many models of dark matter and hidden sectors predict new particles with masses below the electroweak scale. Low-energy electron-positron colliders such as BABAR are ideally suited to discover these hidden-sector particles. We present several recent BABAR searches for low-mass hidden-sector particles, including new searches for prompt and long-lived leptonically decaying hidden scalars produced in association with tau leptons. This search is sensitive to viable models that could account for the muon g-2 excess. We also present results a search for dark muonic forces, and for invisible particles produced in six-quark final states. These examples show the importance of B-factories in constraining and discovering new hidden-sector physics beyond the SM.

Session 2 / **109**

Indirect dark matter detection

Author: Tracy Slatyer[None]

Corresponding Author: tslatyer@mit.edu

I will discuss recent developments in indirect searches for dark matter, including a status update on the strongest current constraints from indirect detection. I will discuss the status of several excesses that have garnered interest as possible signals of dark matter, with a particular focus on the GeV gamma-ray excess in the inner Galaxy.

Session 10 / **13**

Black hole spectroscopy of dark matter and dark sector at future colliders

Author: Ningqiang Song[1]

Co-author: Aaron Vincent [1]

[1] *Queen's University*

Corresponding Author: ningqiang.song@queensu.ca

If the length scale of possible extra dimensions is large enough, the effective Planck scale is lowered such that microscopic black holes could be produced in collisions of high-energy particles at colliders. These black holes evaporate through Hawking radiation of a handful of energetic particles drawn from the set of all kinematically and thermally allowed degrees of freedom, including dark matter. Here, we perform the first numerical black hole spectroscopic study of the dark sector. We find that if the next generation of colliders can produce microscopic black holes, then missing momentum signatures can reveal the existence of any new light (less than 10 TeV) particle, regardless of the strength of its coupling to the Standard Model, even if there exists no such non-gravitational coupling at all.

Session 14 / **50**

Searching for Dark Matter with Paleo-Detectors

Author: Patrick Stengel[1]

[1] *Stockholm University*

Corresponding Author: patrick.stengel@fysik.su.se

A large experimental program is underway to extend the sensitivity of direct detection experiments, searching for interaction of Dark Matter with nuclei, down to the neutrino floor. However, such experiments are becoming increasingly difficult and costly due to the large target masses and exquisite background rejection needed for the necessary improvements in sensitivity. We investigate an alternative approach to the detection of Dark Matter-nucleon interactions: Searching for the persistent traces left by Dark Matter scattering in ancient minerals obtained from much deeper than current underground laboratories. We estimate the sensitivity of paleo-detectors, which extends far beyond current upper limits for a wide range of Dark Matter masses. The projected sensitivity of our proposal also far exceeds the upper limits set by Snowden-Ifft et al. more than three decades ago using ancient Mica in an approach similar to paleo-detectors.

Session 3 / **121**

Primordial Black Holes as dark matter

Corresponding Author: vtakhist@physics.ucla.edu

Session 12 / **84**

Recent Results and Current Status of COSINE-100

Author: William Thompson[1]

[1] *Yale University*

Corresponding Author: william.thompson@yale.edu

COSINE-100 is a direct detection dark matter experiment that is testing DAMA/LIBRA's claim of dark matter discovery. Located in South Korea's Yangyang Underground Lab, COSINE-100 comprises 106 kg of sodium iodide detectors surrounded by a ˜2000 L liquid scintillator veto. In this talk, I will discuss recent results from our experiment, including searches for a dark matter-induced annual modulation signal and for coherent WIMP-nucleus scattering. I will also detail analysis efforts currently underway, featuring a reduced energy threshold of 1 keV and three years of data.

Session 11 / **126**

Dark matter study with Giant Telescopes

Author: Tommaso Treu[1]

[1] *UCLA*

Corresponding Author: tt@astro.ucla.edu

.

Final talk / **147**

Final Talk

Author: Michael Turner[1]

[1] *University of Chicago*

Corresponding Author: mturner@kicp.uchicago.edu

Final talk of the conference.

Session 16 / **27**

The SENSEI Experiment: Status and Plans

Author: Sho Uemura[1]

[1] *Tel Aviv University*

Corresponding Author: meeg@slac.stanford.edu

I will present results from ongoing characterization of the skipper CCD technology, and progress towards deployment of the 100-gram experiment using a new generation of skipper CCDs at the SNOLAB deep underground facility.

Session 16 / **28**

Low Mass Dark Matter Searches with SuperCDMS and CUTE

Author: Ryan Underwood[1]

[1] *Queens University*

Corresponding Author: 14reu@queensu.ca

The Super Cryogenic Dark Matter Search (SuperCDMS) employs cryogenic germanium and silicon detectors to search for dark matter with a focus on low-mass dark matter particles. As SuperCDMS prepares for the next generation facility to come online at SNOLAB, new detectors are tested at the Cryogenic Underground TEst facility (CUTE), which provides a low-background environment and thus presents the opportunity to take advantage of the very low thresholds of these new detectors for potential early searches for low-mass dark matter.

This talk will cover the recently published results from a search for low-mass dark matter signals in electron-recoil data from SuperCDMS Soudan as well as the ongoing detector testing and emerging opportunities for early low-mass dark matter searches at CUTE.

Session 18 / **22**

Status of the CYGNUS Directional Recoil Observatory Project

Author: Sven Vahsen[1]

[1] *University of Hawaii (US)*

Corresponding Author: sevahsen@hawaii.edu

A large directional nuclear recoil observatory could be used to observe and distinguish different neutrino sources, to search for dark matter in the presence of irreducible background, including neutrinos, and to demonstrate the cosmological origin of a dark matter signal. With WIMP-nucleon scattering limits approaching the neutrino floor, and coherent neutrino-nucleon scattering experimentally established, there is increased interest in such an observatory. The CYGNUS proto-collaboration aims to deploy an underground network of Time Projection Chambers (TPCs). I will review recent work carried out within CYGNUS, including R&D on new readouts, construction of prototypes, and physics sensitivity studies.

Session 17 / **141**

First Operation of the HAYSTAC Dark Matter Axion Experiment with a Squeezed-State Receiver

Author: Karl van Bibber[1]

[1] *University of California Berkeley*

Corresponding Author: karl.van.bibber@berkeley.edu

The Haloscope At Yale Sensitive To Axion Cold dark matter (HAYSTAC) is a pathfinder and an innovation testbed for the 2.5-12 GHz (10-50 μeV) mass range. Operational since 2015, it has from the beginning utilized Josephson Parametric Amplifiers which have enabled it to achieve a system noise temperature at only 2x the Standard Quantum Limit (SQL), and thus probe in the QCD model band at masses in the 6 GHz range, despite its small volume (1.5 L). We have now implemented a receiver based on a Squeezed-vacuum State Receiver (SSR) in the 4-5 GHz range, which evades the SQL entirely. Coupled with improvements in thermal design, the scan rate has been accelerated by a factor of 5-10, and thermal improvements to be incorporated in the next run should result in another factor of 2 speedup. The status of the experiment and first results from the SSR will be discussed, demonstrating sensitivity to axions at (1.5-2)x the KSVZ model coupling. HAYSTAC is one of the

first experiments in the domain of particle astrophysics and cosmology that has utilized squeezed states of vacuum in actual data production, along with LIGO.

RECEPTION and POSTER SESSION IN THE SAME ROOM / 146

Revisiting Constraints Placed on Sub-Lunar Mass Primordial Black Holes

Authors: Gabriel Vasquez[1]; Christopher Hirata[1]; Makana Silva[1]; Paulo-Montero Camacho[2]

[1] *Ohio State University*

[2] *Ohio Sate University*

Corresponding Author: vasquez.119@buckeyemail.osu.edu

Primordial black holes are the only dark matter candidate that does not invoke a new elementary particle that survives to the present day, primordial black holes (PBHs) have garnered a lot of attention recently. Up to now, various observations have strongly constrained most of the mass range for PBHs, leaving only small ranges where PBHs could make up a substantial fraction of the dark matter. Here we revisit the PBH constraints for the asteroid-mass range,i.e., the mass range $3.5\times10^{-17}M_{sun} < m_{PBH} < 4\times10^{-12}$ M_{sun}. In particular, we will be focusing on the constraints on the destruction of white dwarfs by PBHs passing through them while also discussing constraints placed due to optical microlensing and dynamical capture of PBHs by stars.

Session 13 / 43

Discrimination of electron recoils from nuclear recoils in two-phase xenon time projection chambers

Author: Vetri Velan[1]

[1] *University of California, Berkeley*

Corresponding Author: vvelan@berkeley.edu

The two-phase liquid xenon time projection chamber is one of the leading technologies used for dark matter direct detection. World-leading limits on dark matter interactions have been set by LUX and XENON1T, and the upcoming LZ and XENONnT experiments seek to push further. A crucial part of using this technology is being able to classify energy deposits as nuclear recoils (NR) or electron recoils (ER). In my talk, I will discuss how ER-NR discrimination can influence the performance of future detectors, informed by our analysis of LUX calibration data. I will focus on this via two paradigms: effects on discrimination from detector parameters like electric field and light collection, and from physical variables like pulse-shape and energy. I will also discuss the physical origins of fluctuations in electron recoil signals and how LUX data can inform our understanding of these effects.

Session 17 / 89

Tunable axion plasma haloscopes

Authors: Matthew Lawson[1]; Alexander Millar[2]; Matteo Pancaldi[1]; Frank Wilczek[1]; Edoardo Vitagliano[None]

[1] *Stockholm University*

[2] *Max Planck Institute for Phyiscs*

Corresponding Author: edovita@mpp.mpg.de

We discuss a new strategy for searching for dark matter axions using tunable cryogenic plasmas. Unlike current experiments, which repair the mismatch between axion and photon masses by breaking translational invariance (cavity and dielectric haloscopes), a plasma haloscope enables resonant conversion by matching the axion mass to a plasma frequency. A key advantage is that the plasma frequency is unrelated to the physical size of the device, allowing large conversion volumes. We identify wire metamaterials as a promising candidate plasma, wherein the plasma frequency can be tuned by varying the interwire spacing. For realistic experimental sizes, we estimate competitive sensitivity for axion masses of 35–400 μeV, at least.

RECEPTION and POSTER SESSION IN THE SAME ROOM / 78

Solar Axion Searches with the International Axion Observatory (IAXO) and BabyIAXO

Authors: Julia Katharina Vogel[1]; Kerstin Perez[2]

Co-authors: Igor Garcia Irastorza [3]; Maurizio Giannotti [4]; Jaime Ruz Armendariz [1]; Michael James Pivovaroff [1]; Klaus Desch [5]

[1] *Lawrence Livermore Nat. Laboratory (US)*

[2] *MIT*

[3] *Universidad de Zaragoza (ES)*

[4] *Barry University*

[5] *University of Bonn*

Corresponding Authors: julia.vogel@cern.ch, kmperez@mit.edu

The International Axion Observatory (IAXO) is a next-generation axion helioscope aiming at a sensitivity to the axion-photon coupling down to ~10^{-12} GeV^{-1}, ~1.5 orders of magnitude beyond current helioscopes. IAXO will probe QCD axions in the 1 meV~1 eV mass range, where they could constitute all or part of the dark matter in the Universe, as well as a large part of parameter space that includes ALP dark matter candidates and other novel excitations at the low-energy frontier of particle physics. As a preliminary step towards a full IAXO experiment, the collaboration is currently constructing BabyIAXO. BabyIAXO will not only serve as a testbed for prototype magnet, optic, and detector systems, but also probe four times lower in axion-photon coupling than the current leading helioscope limits. Both, IAXO and BabyIAXO rely on three major components: a powerful magnet, x-ray focusing optics and ultra-low background x-ray detector. In this contribution, we discuss the status of BabyIAXO and IAXO, as well as the anticipated science impact of each.

Session 16 / 87

Low Mass Wimp Search with a Liquid Argon TPC

Authors: TBD[None]; DarkSide Collaboration[None]

Corresponding Author: shawest@physics.carleton.ca

The DarkSide collaboration demonstrated the ability of a dual-phase LAr-TPC to search for low-mass dark matter candidates, including light WIMPs with masses below 10- GeV and sub-GeV particles that interact with couplings smaller than the weak scale, by exploiting the high electron extraction efficiency and the inherent gain of the ionization signal of the DarkSide-50 detector. A LAr-TPC designed specifically to optimize the ionization channel could realistically

push the experimental sensitivity to low-mass DM down to the solar neutrino floor. We will detail the experimental challenges related to this goal and introduce efforts currently underway to address these issues. Finally, we'll present projections of the sensitivity a future, tonne-scale LAr-TPC could achieve.

Session 12 / **145**

Dark Matter Search Results from DEAP-3600

Author: Shawn Westerdale[1]

[1] *Princeton University*

Corresponding Author: swesterdale@gmail.com

DEAP-3600 is a dark matter direct detection experiment located 2 km underground at SNOLAB (Sudbury, Canada). This single-phase detector consists of 3.3 tonnes of liquid argon (LAr), with an array of 255 photomultiplier tubes viewed through 50 cm of acrylic. The collaboration released dark matter search results from the first year of running (November 2016 to October 2017) last year, with a total live time of 231 days, and it is currently finishing the analysis of the latest blinded dataset. This talk will detail the analysis underlying these results and an update of the current analysis, which constitute the most sensitive search performed with a LAr target for WIMPs with a mass greater than 30 GeV.

Session 17 / **99**

The Search for Axion Dark Matter Below 1 micro-eV: ABRACADABRA-10cm Current Results and Designing the DMRadio-mˆ3

Author: Lindley Winslow[None]

Corresponding Author: lwinslow@mit.edu

ABRACADABRA-10cm (ABRA-10cm) is a pathfinder experiment searching for axion dark matter (ADM) in the well-motivated parameter space for masses below 1 micro-eV. The next-generation experiment DMRadio-m3 brings together the expertise developed for the ABRA-10cm and DMRadio Pathfinder efforts and is being developed under the DOE Dark Matter New Initiatives program. In this talk, I will review the motivation, concept, and plans for searching for ADM below 1 micro-eV. I will present the results from our first one month search for axions with ABRA-10cm, updates from our second physics run and our plans towards a cubic meter scale experiment, DMRadio-mˆ3.

Session 1 / **113**

Cosmology, data, and statistics

Corresponding Author: wright@astro.ucla.edu

Cosmology has advanced from "2.5 facts" in 1963 to a very data-rich field today. This has led to the determination of the baryon density, the dark matter density, and the dark energy density. But more facts lead to a greater reliance on advanced statistical techniques, which are usually useful but occasionally misleading.

It is important to consider "look elsewhere effects", and to remember that even the true model will not fit all the data. In this talk I will discuss the most secure benchmarks in the current observational landscape.

Session 10 / **45**

Uncertainties in Direct Dark Matter Detection in Light of Gaia's Escape Velocity Measurements

Author: Youjia Wu[1]

Co-authors: Katherine Freese [1]; Chris Kelso [2]; Patrick Stengel [3]; Monica Valluri [1]

[1] *University of Michigan*

[2] *University of North Florida*

[3] *Stockholm University*

Corresponding Author: wuyoujia12@gmail.com

Direct detection experiments have set increasingly stringent limits on the cross section for spin-independent dark matter-nucleon interactions. In obtaining such limits, experiments primarily assume the standard halo model (SHM) as the distribution of dark matter in our Milky Way. Three astrophysical parameters are required to define the SHM: the local dark matter escape velocity, the local dark matter density and the circular velocity of the sun around the center of the galaxy. This work studies the effect of the uncertainties in these three astrophysical parameters on the XENON1T exclusion limits using the publicly available DDCalc code. We compare limits obtained using the widely assumed escape velocity from the RAVE survey and the newly calculated escape velocity by Monari et al. using Gaia data. Our study finds that the astrophysical uncertainties are dominated by the uncertainty in the escape velocity (independent of the best fit value) at dark matter masses below 6 GeV and can lead to a variation of nearly 6 orders of magnitude in the exclusion limits at 4 GeV. Above a WIMP mass of 6 GeV, the uncertainty becomes dominated by the local dark matter density, leading to uncertainties of factors of ~10 (3) at 6 (15) GeV WIMP mass in the exclusion limits. Additionally, this work finds that the updated best fit value for the escape velocity based on Gaia data leads to only very minor changes to the effects of the astrophysical uncertainties on the XENON1T exclusion limits.

Session 17 / **80**

Recent Results from Axion Dark Matter eXperiment (ADMX).

Author: Jihee Yang[1]

[1] *University of Washington*

Corresponding Author: jhyang14@uw.edu

The QCD axion is a compelling dark-matter candidate. The axion is a hypothetical particle, arising from the Pecci-Quinn solution to the strong CP problem in quantum chromodynamics. The Axion Dark Matter eXperiment (ADMX) is searching for cold dark matter axions in the halo of our galaxy. ADMX is the largest operating axion haloscope. It consists of a high-Q microwave resonator immersed in a strong magnetic field, which serves to convert the axions into microwave photons. The axion-photon coupling is somewhat model dependent, but the DFSZ model is particularly compelling. After recent upgrades, ADMX has successfully completed axion searches with sensitivity to DFSZ axions, a milestone in axion research. Key to this result were low physical temperatures from

a dilution refrigerator and a low noise microwave receiver based on quantum electronics. We will present an overview of ADMX and the recent axion search results. We will also outline our future search plans.

Session 12 / **44**

Status of PandaX dark matter experiments

Author: yong yang[1]

[1] *Shanghai Jiao Tong University*

Corresponding Author: yong.yang@sjtu.edu.cn

PandaX dark matter experiments use liquid xenon as target to search for dark matter particles at the China Jinping Underground Laboratory. The second phase of the experiments, PandaX-II, with 580 kg liquid xenon in the sensitive volume, has finished data taking in 2019 and collected 140 ton day of dark matter search data set in total. The next experiment under preparation, PandaX-4T, with 4 ton liquid xenon in the sensitive volume, is expected to improve the detection sensitivity by one order of magnitude compared to PandaX-II. I this talk, I will discuss recent progress and status of the PandaX dark matter experiments.

Session 17 / **107**

CAPP18T axion dark matter search experiment at KAIST/IBS

Author: JONGHEE YOO[1]

[1] *KAIST*

Corresponding Author: yoo.jonghee@gmail.com

The matter component of the Universe is mostly filled with what we cannot see; dark matter. The existence of dark matter is a crucial phenomenological evidence for physics Beyond the Standard Model. Among the dark matter candidate particles, the Weakly Interacting Massive Particles (WIMPs) and the Axions are the most outstanding contender. In this talk, I will discuss about the recent progress of axion dark matter search experiment using 18T high temperature superconducting magnet in KAIST/IBS.

RECEPTION and POSTER SESSION IN THE SAME ROOM / **31**

Mono- W′: searching for dark matter in events with a hadronically decaying W′ and missing transverse energy

Author: Kyungseop Yoon[1]

Co-authors: Daniel Whiteson [1]; Matteo Cremonesi [2]; Tim M.P. Tait [3]

[1] *University of California Irvine (US)*

[2] *Fermi National Accelerator Lab. (US)*

[3] *University of California, Irvine*

Corresponding Author: kyungseop.yoon@cern.ch

We analyze the potential dark matter implications of LHC events with missing transverse momentum and a W′ resonance, decaying via $t\bar{b}$ to a hadronic final state. This final state remains unexamined by LHC experiments, but contains significant new discovery potential. We introduce a benchmark model for production of a W′ boson in association with dark matter, propose reconstruction and selection strategies, and estimate the sensitivity of the current LHC dataset.

RECEPTION and POSTER SESSION IN THE SAME ROOM / 135

Entering in the Era of Dark Matter Astronomy: Galactic DM Sensitivities in the X-ray and Gamma-ray Band

Authors: Dawei Zhong[None]; Kevork N. Abazajian[None]; Mauro Valli[1]

[1] *University of California, Irvine*

Corresponding Author: dzhong4@uci.edu

Dark matter (DM) accounts for 85% of matter in the universe, but its particle properties still remain unknown. Several studies have focused on X-ray and γ-ray signals of DM from the Milky Way, other L* galaxies and galaxies clusters. With the help of upcoming advanced detectors, it is expected to find DM astronomical smoking gun in the future. In this project, we evaluate Galactic DM radiation and detectability based on spatial and kinematic information extracted from the "m12i" galaxy in Latte suite of Feedback In Realistic Environments (FIRE-2). In particular, we estimate the all-sky centroid energy shift patterns of DM narrow emission lines and discuss its potential as DM signal diagnosis with symmetric observations about $\ell = 0^o$. Specifically, with an exposure at $\ell \sim 90^o$ and $\ell \sim 270^o$ (-90^o), the spectrometers on future X-ray telescopes XRISM, Athena and Lynx have the capability to perform DM diagnosis for Galactic DM decay emission line at ~ 3.5 keV. Finally, we present all-sky luminosity maps for both DM annihilation and decay signals and evaluate the signal-to-noise (S/N) for DM detections taking into account realistic X-ray and γ-ray backgrounds. Our study aims to be a valuable guideline for the forthcoming era of DM astronomy.

Session 5 / 137

A New Mask for An Old Suspect: Testing the Sensitivity of the Galactic Center Excess to the Point Source Mask

Author: Yiming Zhong[1]

[1] *KICP, U of Chicago*

Corresponding Author: ymzhong@kicp.uchicago.edu

The Fermi-LAT collaboration has recently released a new point source catalog, referred to as 4FGL. For the first time, we perform a template fit using information from this new catalog and find that the Galactic center excess is still present. On the other hand, we find that a wavelet-based search for point sources is highly sensitive to the use of the 4FGL catalog: no excess of bright regions on small angular scales is apparent when we mask out 4FGL point sources. We postulate that the 4FGL catalog contains the large majority of bright point sources that have previously been suggested to account for the excess in gamma rays detected at the Galactic center in Fermi-LAT data. Furthermore, after identifying which bright sources have no known counterpart, we place constraints on the luminosity function necessary for point sources to explain the smooth emission seen in the template fit.

Session 3 / **102**

Particle Dark Matter: Status and Prospects

Author: Kathryn Zurek[1]

[1] *Caltech*

Corresponding Author: kzurek@caltech.edu

Overview of particle dark matter models.

Session 17 / **142**

The CASPEr nuclear magnetic resonance search for ultra-light axion-like dark matter

Author: Alex Sushkov[1]

[1] *Boston University*

The nature of dark matter is one of the most important open problems in modern physics. Axions and axion-like particles (ALPs) are strongly-motivated ultra-light dark matter candidates. Nuclear spins interacting with axion-like background dark matter experience a torque, oscillating at the axion Compton frequency. The Cosmic Axion Spin Precession Experiments (CASPEr) use precision magnetometry and nuclear magnetic resonance techniques to search for the effects of this interaction. I will describe how we use this approach to place new limits on interactions of axion-like dark matter in a broad mass range.

Session 8 / **144**

Dark photon and light dark matter searches at Belle II

Author: Ewan Chin Hill[1]

[1] *University of Victoria (CA)*

The Belle II experiment at the SuperKEKB energy-asymmetric e^+e^- collider is a substantial upgrade of the B factory facility at the Japanese KEK laboratory. The design luminosity of the machine is 8×10^{35} cm^{-2}s^{-1} and the Belle II experiment aims to record 50 ab^{-1} of data, a factor of 50 more than its predecessor. During 2018, the machine has completed a commissioning run, recording a data sample of about 0.5 fb^{-1}. Main operations started in March 2019 with the complete Belle II detector: an integrated luminosity of 10 fb^{-1} has been collected so far. These early data sets, with specifically designed low multiplicity triggers, offer already the possibility to search for a large variety of dark sector particles in the GeV mass range, complementary to LHC and to dedicated low energy experiments. The talk will review the status of the dark sector searches at Belle II, with a focus on the discovery potential of the early data, and show the first results.