CETUP* 2023

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Lead/Deadwood Middle School

Book of Abstracts

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Low-Energy Supernovae Bounds on Sterile Neutrinos

Author: Garv Chauhan[1]

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Sterile neutrinos can be produced through mixing with active neutrinos in the hot and dense core of a collapsing supernova (SN). The standard SN bounds on the active-sterile mixing arise from the SN1987A energy-loss argument. In this talk, I will discuss a novel and stringent bound on the mixing arising from the energy deposition through the decays of sterile neutrinos inside the SN envelope.

2

Radiative corrections in neutrino physics

Author: Oleksandr Tomalak[1]

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In this talk, I will motivate and describe a few recent precise calculations of radiative corrections to neutrino oscillation and cross-section experiments. I will present elastic neutrino-electron, inverse muon decay cross sections, and neutrino energy spectra from radiative muon, pion, and kaon decays, with quantified uncertainties. I will formulate radiative corrections to charged-current elastic neutrino-nucleon scattering and validate the precise relation between electron and muon flavor cross sections for signal events in neutrino oscillation experiments. I will illustrate permille-to-percent level effects on (anti)neutrino- and electron-nucleus scattering cross sections due to the exchange of photons with a nuclear medium.

3

An Analytic Approach to Light Dark Matter Attenuation

Author: Christopher Cappiello[None]

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Although searches for GeV-scale WIMPs are sensitive to very small cross sections, constraints on sub-GeV dark matter are significantly weaker, and largely constrain moderately- or strongly-interacting dark matter. But if dark matter interacts too strongly with nuclei, it could be slowed to undetectable speeds in Earth's crust or atmosphere before reaching a detector. For sub-GeV dark matter, approximations used to model the attenuation of heavier dark matter fail, necessitating the use of computationally expensive simulations. I present a new, analytic approximation for modeling attenuation of light dark matter in the Earth. I show that our approach agrees well with Monte Carlo results, and can be much faster at large cross sections. I show how this method can be used to reanalyze recently reported constraints on sub-dominant dark matter—that is, dark matter particles that make up only a fraction of the total dark matter density.

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The gamma-ray galactic center excess with multi-messenger observations

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Co-authors: Joseph Surdutovich [2]; Sam McDermott [3]; YiMing Zhong [4]

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The Galactic center excess (GCE) remains one of the most intriguing discoveries from the Fermi Large Area Telescope (LAT) observations. I will revisit characteristics of the GCE tested under an updated set of high-resolution galactic diffuse gamma-ray emission templates. This diffuse emission, which accounts for the bulk of the observed gamma rays, is ultimately due to cosmic-ray interactions with the interstellar medium. Using recent high-precision cosmic-ray observations, in addition to the continuing Fermi-LAT observations and observations from lower energy photons. I will discuss improvements on modeling of the galactic diffuse emission. A large set of diffuse gamma-ray emission templates has been used which account for a very wide range of initial assumptions on the physical conditions in the inner galaxy. I will give an update on the spectral and morphological properties of the GCE and their physical implications.

5

Low-Energy Atmospheric Neutrino Oscillations

Author: Kevin Kelly[1]

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Neutrino oscillation physics is a rich phenomenon, especially when any of the following is true: the neutrinos have low energy, the travel distance is large, and interactions with matter are significant along the path of propagation. All three of these criteria are met in low-energy atmospheric neutrino oscillations. I will demonstrate how this class of oscillations is exciting for several applications, and discuss which next-generations are best suited to exploit such measurements.

6

Energy-dependent neutrino mixing parameters at oscillation experiments

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Neutrino mixing parameters are subject to quantum corrections and hence are scale dependent. This means that the mixing parameters associated with the production and detection of neutrinos need not coincide since these processes are characterized by different energy scales. We show that, in the presence of relatively light new physics, the scale dependence of the mixing parameters can lead to observable consequences in long-baseline neutrino oscillation experiments, such as T2K and NOvA, and in neutrino telescopes like IceCube. We discuss the experimental signatures of this scenario in detail.

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Light Dark Matter Accumulating in Terrestrial Planets: Nuclear Scattering

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The direct capture and accumulation of Galactic dark matter in
astrophysical bodies can occur as a result of its scattering with nuclei. In this work we investigate the detailed capture and evaporation of dark matter in terrestrial planets, taking Earth as an example. We focus on the strongly interacting case in which Earth may be opaque to dark matter, referred to as the optically thick" limit. We investigate light dark matter in particular, addressing important dynamical processes such as theping-pong effect" during dark matter capture and the heating of Earth by dark matter annihilation. We do this using Monte-Carlo simulations as well as detailed analytical computations, and obtain improved bounds on dark matter direct detection for both spin dependent and spin-independent scattering, and also allowing for the interacting species to make up a sub-component of the dark matter density.

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Light Sterile Neutrinos: A Modern Picture and a Model to Evade Cosmology

Authors: Peter Denton[1]; Hooman Davoudiasl[1]

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I will review existing hints and constraints on light sterile neutrinos. I will then explain the primary reasons why these anomalous data sets cannot be simply interpreted as a 1 eV sterile neutrino due to constraints from other experimental probes, notably solar neutrinos and cosmological data sets. I will present a novel, simple model that evades many of these constraints by adding in one new particle, which is the dark matter, beyond a sterile neutrino leading to shape-shifting sterile neutrinos.

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Here Comes the Sun: Solar Parameters in Long-Baseline Accelerator Neutrino Oscillations

Author: Julia Gehrlein[1]

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Long-baseline (LBL) accelerator neutrino oscillation experiments, such as
NOvA and T2K in the current generation, and DUNE-LBL and HK-LBL in the coming years, will measure the remaining unknown oscillation parameters with excellent precision. These analyses assume external input on the solar parameters, θ_{12} and Δm^2_{21}, from solar
experiments such as SNO, SK, and Borexino, as well as reactor experiments like Kam-LAND. Here we investigate their role in long-baseline experiments. We show that, without input on solar parameters, the sensitivity to detecting and quantifying CP violation is
significantly, but not entirely, reduced. Thus long-baseline accelerator experiments can actually determine the solar parameters, and thus all six oscillation parameters, without input from any other oscillation experiment. In particular, Δm^2_{21} can be determined; thus
DUNE-LBL and HK-LBL can measure both the solar and atmospheric mass splittings in their long-baseline analyses alone. While their sensitivities are not competitive with existing constraints, they are very orthogonal probes of solar parameters and provide a key consistency check of a less probed sector of the three-flavor oscillation picture. Further-
more, we also show that the true values of the solar parameters play an important role in the sensitivity of other oscillation parameters such as the CP violating phase δ.

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Putting all the X in one basket: X-ray constraints on sub-GeV dark matter

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In this talk I will focus on light dark matter particles, with a mass between 1 MeV and a few GeV. These particles can annihilate or decay into electron-positron pairs which can upscatter the low-energy fields in our Galaxy and produce X-ray emission. By using the X-ray data from XMM-Newton, Integral, Suzaku and NuSTAR, we derive strong constraints on MeV dark matter. In the decay scenario, our bounds are the strongest to date for dark matter masses above 100 MeV and improving up to 3 orders of magnitude upon existing limits. In the annihilation case, our constraints are the strongest available for dark matter masses above 180 MeV.

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Probing Sub-GeV Dark Matter with the HeRALD Detector

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The TESSERACT collaboration will search for dark matter particles below the proton mass through interactions with two types of novel, ultra-sensitive detectors, These detectors, SPICE & HeRALD, aim to provide leading sensitivities to low mass dark matter candidates. The HeRALD experiment will use superfluid He4 as a target material, which is an ideal kinematic match for dark matter nuclear

recoils. Both detectors will be read out by Transition Edge Sensors (TES) that are sensitive to phonon, roton, and light signals from LHe. In this talk I will be discussing the current R&D progress on HeRALD at LBNL, UC Berkeley, and UMASS Amherst. Lastly, I will briefly discuss progress on the eventual underground detector.

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FIMP Dark Matter from Flavon Portals

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We investigate the phenomenology of a non-thermal dark matter (DM) candidate in the context of flavor models that explain the hierarchy in the masses and mixings of quarks and leptons via the Froggatt-Nielsen (FN) mechanism. A flavor-dependent $U(1)_{FN}$ symmetry explains the fermion mass and mixing hierarchy, and also provides a mechanism for suppressed interactions of the DM, assumed to be a Majorana fermion, with the Standard Model (SM) particles, resulting in its FIMP (feebly interacting massive particle) character. Such feeble interactions are mediated by a flavon field through higher dimensional operators governed by the $U(1)_{FN}$ charges. We point out a natural stabilizing mechanism for the DM within this framework with the choice of half-integer $U(1)_{FN}$ charge n for the DM fermion, along with integer charges for the SM fermions and the flavon field. In this flavon portal scenario, the DM is non-thermally produced from the decay of the flavon in the early universe which becomes a relic through the freeze-in mechanism. We explore the allowed parameter space for this DM candidate from relic abundance by solving the relevant Boltzmann equations. We find that reproducing the correct relic density requires the DM mass to be in the range (100–300) keV for n = 7.5 and (3–10) MeV for n = 8.5 where n is the $U(1)_{FN}$ charge of the DM fermion.

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Neutrinos at a Forward Physics Facility: Production, Interactions and Astroparticle Physics Connections

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Neutrino experiments at a proposed Forward Physics Facility (FPF) would collect neutrino and antineutrino interaction data from one million muon neutrinos, 100,000 electron neutrinos and 10,000 tau neutrinos in the High-Luminosity era of the Large Hadron Collider (LHC). Already during Run 3, the experiments FASERv and SND@LHC are installed and collecting data. In the forward region where neutrino rapidities are 6.9 and higher, fluxes of neutrinos extend to few TeV energies. An overview of neutrino forward production at the LHC will be presented. Opportunities for tests of the standard model and searches for BSM physics with these neutrinos will be reviewed. We describe connections between forward neutrino production at the LHC and the atmospheric neutrino flux.

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How Binary-Pulsar Orbital Period Measurements Constrain Baryon Dark Decays

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There are numerous motives (e.g., the baryon asymmetry problem) for considering baryon number violation (BNV) in extensions to the Standard Model. Given our current stringent constraints on BNV from certain experiments (e.g., SuperK), it is natural to examine the consequences of BNV in extreme conditions that are not realized terrestrially. In this talk, I show how the particle physics of BNV within a neutron star can be constrained by baryon-loss limits inferred from anomalous binary-pulsar period lengthening. I then map these limits onto specific models with baryon decays to dark particles for cases in which the produced dark particles do not survive to influence the response of the star to BNV effects. I show how limits on in-vacuum baryon dark decays can be extracted employing the techniques of relativistic mean-field theory, which are appropriate for studying in-medium effects in the dense nuclear medium found at the core of a neutron star. I conclude by noting the implications of our results for models of dark-sector-enabled baryogenesis.

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The Large Magellanic Cloud and dark matter direct detection

Author: Nassim Bozorgnia[1]

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The Large Magellanic Cloud (LMC) can significantly impact the dark matter halo of the Milky Way, and boost the dark matter velocity distribution in the Solar neighborhood. Cosmological simulations that sample potential Milky Way formation histories are powerful tools, which can be used to characterize the signatures of the LMC's interaction with the Milky Way, and can provide crucial insight on the LMC's effect on the local dark matter distribution. I will discuss the impact of the LMC on the local dark matter distribution in state-of-the-art cosmological simulations, and its implications for dark matter direct detection.

16

The three neutrino mixing scenario under the next atmospheric measurements

Author: Ivan Martinez Soler[1]

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We analyze the expected sensitivity of current and near-future water(ice)-Cherenkov atmospheric neutrino experiments in the context of standard three-flavor neutrinos oscillations. In this first in-depth combined atmospheric neutrino analysis, we analyze the current shared systematic uncertainties arising from the shared flux and neutrino-water interactions. We then implement the systematic uncertainties of each experiment in detail and develop the atmospheric neutrino simulations

for Super-Kamiokande (SK), with and without neutron-tagging capabilities (including SuperK-Gd), IceCube-Upgrade, and ORCA detectors. We carefully review the synergies and features of these experiments to examine the potential of a joint analysis of these atmospheric neutrino data in resolving the octant of the atmospheric mixing angle at 99% C.L. and determining the neutrino mass ordering above 5σ by 2030. Additionally, we assess the capability to constraint
the reactor mixing angle and the CP-violating phase in the leptonic sector independently from reactor and accelerator neutrino data, providing vital information for next-generation neutrino oscillation experiments such as DUNE and Hyper-Kamiokande.

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Dark Matter Signals and Constraints from keV to GeV

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The possibility of dark matter residing in the neutrino sector remains of high interest, being probed by X-ray astronomy as well as laboratory searches. I will review candidate structure-formation and X-ray signals and constraints on keV-scale sterile neutrino dark matter. Much interest also remains at a factor of a million higher energy, with the Galactic Center Excess (GCE) of gamma-ray emission that may be consistent with dark matter annihilation at the GeV-scale. I will show: (1) the limitations of recent analyses that find a dark matter preference for the GCE, and (2) employing the latest models of diffuse emission and stellar-bulge associated populations makes them strongly preferred over a dark matter source.

18

Carbon Burning in Massive Stars

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Carbon burning marks the ignition of the third nuclear fuel supply after H- and He-burning in the evolution of massive stars. Since the stellar core temperature is strongly correlated with the stellar mass, a minimum mass is required for carbon ignition. This critical mass limit, common referred to as M_{up}, depends on the reaction rate of the carbon fusion reactions. This parameter determines the upper limit for carbon-oxygen white dwarf progenitors and the lower limit for core collapse supernovae. Consequently, the expected number of CO and ONeMg white dwarfs in a given stellar population and, thus, the rate of type Ia supernovae as well as the number of type II supernova events depend on the carbon fusion reaction rates.
Current estimates of these reaction rates at astrophysical energies rely on extrapolations from higher energy data. Low energy studies of ^{12}C+^{12}C reactions have focused either on charged particle or on γ-ray spectroscopy. Charged particle spectroscopy has the advantage that the total fusion cross section can in principle be measured, while γ-ray spectroscopy (and γ-particle coincidences) cannot account for direct transitions to the ground state of the residual nucleus. However, the condition of being a total cross section measurement is not fulfilled in practice in the case of the particle spectroscopy due to finite energy resolution and low-energy detection limits.
Recently, the Trojan Horse Method (THM) has been exploited to determine the ^{12}C+^{12}C cross section over the entire energy range of the Gamow window. Comparison of these results with information from newly published experiments reveal tension between THM data and direct experiments.
The current status of the carbon fusion cross section and its implication as well as prospects for underground measurements of the carbon fusion reactions will be discussed.

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New physics potential using coherent, low-energy neutrino scattering

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Coherent, elastic neutrino-nucleus scattering (CEvNS) is a low-Q2 neutrino interaction channel, with the neutrino transferring a small, but experimentally detectable, kinetic energy to the nucleus. The first measurement of CEvNS was achieved using the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory by the COHERENT experiment using a 14.6-kg CsI[Na] scintillation crystal. Due to its large and precisely predicted scattering cross section, CEvNS received significant interest for potential discovery of new physics beyond the standard model. In this talk, we discuss first-light CEvNS measurements on CsI and Ar along with future experimental plans precisely measure the process at the multi-ton scale with emphasis on potential constraints of BSM physics. Among topics we will cover are searches for BSM neutrino interactions, limits on sterile neutrinos and exotic oscillations, and searches for dark matter. These large detectors will also allow for a measurement of the weak mixing angle at low Q2 and measurement of the weak charge distribution in of target nuclei.

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Light Neutrinophilic Dark Matter from Scotogenic Model

Authors: Johannes Herms[1]; Shaikh Saad[2]; Sudip Jana[1]; Vishnu Padmanabhan Kovilakam[3]

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We explore a novel possibility of light thermal dark matter within the context of neutrino mass models. In the sub-GeV mass regime, dark matter relic solely annihilates into neutrinos without affecting the Cosmic Microwave Background anisotropies. We have proposed a minimal UV-complete model for this scenario. All new physics states lie at or below the electroweak scale, affecting Higgs physics, neutrinoless double beta decay process, and lepton flavor violating process. We find that the indirect detection of dark matter at large-volume neutrino detectors such as Dune, Hyper-Kamiokande, and JUNO experiments is the most effective way to test this model. Results will be presented.

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Using Neutrinos to understand our Earth's Interior

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The unknown constituents of the interior of our home planet have provoked the human imagination and driven scientific exploration. In the near future, it might be possible to better determine the

Earth's chemical composition by combining observations from large neutrino detectors with seismic measurements of the Earth's matter density and data from high-pressure experiments. The talk will discuss the potential of using neutrino absorption and neutrino oscillation tomography to determine the Earth matter density, and Earth's interior composition, respectively. We will further discuss how Earth interior models impact uncertainties on neutrino oscillation parameters and how to quantify them better.

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Detecting the neutrino flux from inelastic dark matter in the Sun

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Neutrino emission from gravitational capture and subsequent annihilation of elastic dark matter in the Sun is largely constrained due to null results from direct-detection experiments. However, these limits are relaxed for inelastic dark matter. In this talk, we look at the sensitivity of a large volume detector, such as DUNE or Super-Kamiokande, to the neutrino flux originating from the Sun. We estimate the source-pointing resolution of DUNE at these energies which helps in reducing the atmospheric neutrino backgrounds. We find that the neutrino experiments can probe novel parameter space for 10-200 GeV dark matter with 10-200 keV mass-splitting when compared to direct-detection experiments. We present limits from Super-Kamiokande data as well as forecast the sensitivity of DUNE and Hyper-Kamiokande. For dark matter annihilation to light quarks, DUNE offers leading sensitivity whereas for annihilation to heavy quarks, the expected limits from DUNE and Super-Kamiokande are comparable.

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Cosmic Stasis from Primordial-Black-Hole Evaporation and Its Phenomenological Implications

Author: Brooks Thomas[1]

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Cosmic stasis is a phenomenon in which the abundances of multiple cosmological energy components —components such as matter, radiation, or vacuum energy —remain effectively constant despite the expansion of the universe. One mechanism which can give rise to an extended period of

cosmic stasis is the evaporation of a population of primordial black holes (PBHs). In this talk, I review how PBH evaporation can lead to a stasis epoch and examine the observational consequences of such a modification to the cosmic expansion history. These include implications for inflationary observables, for the stochastic gravitational-wave background, and for the production of dark matter and dark radiation.

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Long-Lived Particles, Dark Matter, and Matter-Antimatter Asymmetry

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I discuss how sub-TeV long-lived particles (LLPs) in the visible sector may drive an epoch of early matter domination (EMD). This scenario can accommodate the correct dark matter (DM) relic abundance for both cases with small and large annihilation cross section. I will then present a minimal extension of the standard model that includes a weak-scale LLP and a light DM candidate with O(GeV) mass. The LLP decay at the end of an EMD period yields the correct DM abundance and generates the observed baryon asymmetry of the universe. The parameter space of this model can be probed by proposed LLP searches as well as next-generation neutron-antineutron oscillation experiments.

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SPICE: A Search for Light (MeV - GeV) Dark Matter Using Polar Crystal Calorimeters

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The search for dark matter has recently broadened to focus on a much wider class of candidates, including particle-like dark matter lighter than the traditional WIMP. The SPICE/HeRALD (or TESSERACT) collaboration has been formed to search for light (MeV-GeV) dark matter interactions in a variety of targets read out by TES-based calorimeters. In this talk, we describe the efforts of the SPICE project to search for light dark matter using crystalline targets including the polar crystals GaAs and Sapphire. We will detail specific thrusts of our ongoing R&D efforts: reducing low-energy backgrounds, improving energy resolution, and conducting pathfinder sub-GeV dark matter searches.

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Jet-SIFTing for New Physics

Author: Joel Walker[1]

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We describe a new scale-invariant jet clustering algorithm that does not impose a fixed cone size on a collider event. The proposed construction unifies large-radius jet finding, substructure axis-finding, and recursive filtering of soft wide-angle radiation into a single procedure. The sequential clustering measure history facilitates high-performance substructure tagging with a boosted decision tree. Excellent object discrimination and kinematic reconstruction is maintained for highly-boosted partonic systems, while asymptotically recovering favorable behaviors of both the standard KT anti-KT algorithms.

We explore applications of this new technology to searches for new physics in a collider setting. In particular, we consider a Hidden Valley model which generates high-multiplicity showering from strong dynamics within the dark sector, followed by decays back into Standard Model states. The reconstruction of dark sector masses in such a setting is obscured by a thick combinatoric background. By cutting an ordered slice through possible recombinations, the SIFT algorithm may be able to help lift backgrounds of this variety.

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Searching for New Physics With Astrophysical Neutrinos

Author: Carlos Argüelles-Delgado[1]

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In this contribution I will talk about recent developments on searching for new physics with high-energy astrophysical neutrino sources.

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Dark Sector Signals at Neutrino Experiments

Author: Joshua Berger[1]

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Neutrino experiments will have leading sensitivity to several dark matter and dark sector models. I discuss signals from a range of different dark sector models, from induced nucleon decay in mesogenesis models to production, scattering, and decay of dark sector states in neutrino beams. I present simulation tools for boosted dark matter and induced nucleon decay signals. I discuss some challenges with developing simulation and analyses to achieve a comprehensive program at the SBN and DUNE experiments.

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

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

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Cosmological Implications of Axion Rotations

Author: Raymond Co[1]

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The past decades have seen an explosive growth in searches for axion dark matter, while its cosmological origin has been a theoretical puzzle. The conventional production is the misalignment mechanism, where the abundance arises from a field misalignment from the potential minimum. Nevertheless, this mechanism can naturally explain axion dark matter only in the limited parameter space where experimental reaches are challenging. In this talk, we will present an overview of the latest advancements in axion cosmology and the resulting discoveries of various production mechanisms that will point to the parameter regions much more experimentally accessible. We will highlight the kinetic misalignment mechanism, which makes sharp predictions due to its intriguing connection to the baryon asymmetry of the Universe via axiogenesis.

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A Novel "Beam-Dump" Measurement with CMS for Searching for MeV-Scale Dark-Sector Physics

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We propose a novel scheme for performing a beam-dump-like experiment with the ATLAS/CMS detector. At the LHC, high-energy proton collisions result in jets containing a number of energetic hadrons/electromagnetic objects that are essentially "dumped" to HCAL/ECAL, inducing the production of secondary hadrons, electrons, and photons in calorimetric showers. We envision a situation where MeV-scale dark-sector particles are produced by the interactions of these secondary particles inside HCAL/ECAL. For illustration purposes, we consider the axion-like particles (ALPs) produced via the Primakoff process in the presence of their interaction with photons at CMS. We argue that the DT chambers and the ME0 module of the CMS muon system can serve as detectors to record the photons from the ALP decay, demonstrating that the associated sensitivity reach is competitive due to their close proximity to the signal source points. We further show that the LHC does not suffer from a barrier, dubbed beam-dump "ceiling", that typical beam-dump experiments hardly surpass, carrying the great potential for exploring a wide range of parameter space in increasing statistics.

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Dark matter in main(ish) sequence stars

Author: Aaron Vincent[1]

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Direct detection experiments around the world are searching for the small dark matter-nucleon interactions that would give us the first clue about its particle physics properties. If such interactions exist, they would also cause dark matter to become trapped inside stars. This can have consequences ranging from unobservable to catastrophic: small effects on neutrino fluxes detected at earth, asteroseismologial changes, the formation of black holes in stellar cores, and even premature thermonuclear detonation. I will provide an overview, and focus in on recent developments in modelling main sequence and post-main sequence evolution of stars affected by dark matter.

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Distinctive nuclear signatures of low-energy atmospheric neutrinos

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We examine the possibility of detecting atmospheric neutrinos using the nuclear reactions in large-scale neutrino detectors. The proposed methods allow to measure the low-energy atmospheric rate to a level of approximately 10-30\% depending on the efficiency of the background discrimination techniques. In addition, a better understanding of the low-energy atmospheric neutrino background is essential to improve the detection perspective of the diffuse supernova neutrino background and the direct detection of dark matter.

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Lighter QCD Axion

Author: Kunfeng Lyu[1]

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We propose a model to realize the lighter QCD axion. Exploiting the mirror sector, the minimum position of the total potential is still at origin which does not spoil the solution to the strong CP problem. The axion mass can be reduced by tuning the amplitude of the potential from the mirror sector. There are interesting phenomenology during the cosmological evolution history. The parameter space to produce the correct dark matter relic abundance can be probed in the future experiments.

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Primordial Black Hole Dark Matter from Scalar Fields and Fundamental Forces

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Primordial black holes (PBHs) from the early Universe constitute an attractive non-particle dark matter (DM) candidate. I will present several generic mechanisms of PBH formation based on scalar fields, highlighting how astrophysical signatures of PBHs can help distinguish them. Intriguingly, microlensing observations could be pointing to first hints of PBHs associated with yet unexplored regimes of the fundamental QCD strong force dynamics or bubble multiverse. I will further highlight connections of PBHs with various astronomical puzzles and signatures, charting prospects for discovery.

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Leptogenesis triggered by a first-order phase transition

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We propose a new scenario of leptogenesis, which is triggered by a first-order phase transition (FOPT). The right-handed neutrinos (RHNs) are massless in the old vacuum, while they acquire a mass in the new vacuum bubbles, and the mass gap is huge compared with the FOPT temperature. The ultra-relativistic bubble walls sweep the RHNs into the bubbles, where the RHNs experience fast decay and generate the lepton asymmetry, which is further converted to the baryon asymmetry of the Universe (BAU). Since the RHNs are out of equilibrium inside the bubble, the generated BAU does not suffer from the thermal bath washout. We first discuss the general feature of such a FOPT leptogenesis mechanism, and then realize it in an extended B−L model. The gravitational waves from U(1)B−L breaking could be detected at the future interferometers.

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Asteroid-mass Dark Matter

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Massive astrophysical compact halo objects have been proposed as possible constituents of dark matter today. The mass range of massive compact object DM candidates is quite extensive. Within the broad mass spectrum, the asteroid-mass window has recently received much attention, especially in relation to primordial black holes (PBHs). In this talk, I will first discuss the searches for asteroid-mass PBHs and what we can learn about the dark sector through their Hawking radiation. In the second part, I will introduce a novel dynamic approach to search for massive compact object DM. I will show the gravitational interaction between PBHs and sub-solar mass DM with binary systems presents a potential strategy for probing unexplored parameter spaces.

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Neutrinos from the Sun can discover dark matter-electron scattering

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We probe dark matter-electron scattering using high-energy neutrino observations from the Sun. Dark matter (DM) interacting with electrons can get captured inside the Sun. These captured DM may annihilate to produce different Standard Model (SM) particles. Neutrinos produced from these SM states can be observed in IceCube and DeepCore. Although there is no excess of neutrinos from the Solar direction, we find that the current data-sets of IceCube and DeepCore set the strongest constraint on DM-electron scattering cross section in the DM mass range 10 GeV to 10^5 GeV. Our work implies that future observations of the Sun by neutrino telescopes have the potential to discover DM-electron interactions.

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Electromagnetic Properties of Neutrinos: Past, Present and Future

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After a brief introduction to neutrino electromagnetic properties, I will focus on the correlation between neutrino magnetic moment and neutrino mass mechanism. Then I will discuss that the models that induce large neutrino magnetic moments while maintaining their small masses naturally also predict observable shifts in the charged lepton anomalous magnetic moment by showing that the measurement of muon g−2 by the Fermilab experiment can be an in-direct and novel test of the neutrino magnetic-moment hypothesis, which can be as sensitive as other ongoing-neutrino/dark matter experiments. Such a correlation between muon g−2 and the neutrino magnetic moment is generic in models employing leptonic family symmetry to explain a naturally large neutrino magnetic moment. The promising new possibilities for probing neutrino electromagnetic properties in future experiments from terrestrial experiments and astrophysical considerations will also be discussed. This talk will be based on results obtained in hep-ph 2203.01950, 2007.04291, 2104.03291, and 2303.13572.

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Adventures in the Continuum: Model Building for Hidden Sectors

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We present recent work on hidden sector model building based on particles with a continuous mass spectrum. In the past, these have been known as models with warped extra dimension, near-conformal field theories, hidden valleys, and unparticles. While these ideas saw a golden age as speculations for electroweak physics ahead of the LHC, they may find a new life in hidden sector physics. We focus on continuum mediators and dark matter, focusing on recent work and open questions.

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Gauged Flavor U(1). Fermion Masses and Leptogenesis

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The neutrino data can't be accommodated within the SM.
Origin of the observed Hierarchies between charged fermion masses and CKM matrix elements remain unexplained within the SM. Also the neutrino data can't be accommodated and enough amount of the baryon asymmetry can't be generated within the SM.

We consider simple extension by non-anomalous U(1) flavor symmetry, which gives natural explanation of fermion flavor and, including the right handed neutrinos, gives successful (and very specific) neutrino oscillation scenario. Also baryon asymmetry can be generated through the low scale resonant leptogenesis.
Other interesting properties and phenomenological implications, of the proposed model, will be also discussed.

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Cosmic-ray Neutrino Boosted Dark Matter (νBDM)

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We propose a novel mechanism of boosting dark matter by cosmic-ray neutrinos. The new mechanism is so significant that the arriving flux of cosmic-ray neutrino boosted dark matter (νBDM) lighter than O(1) MeV on Earth substantially larger than the one of the cosmic-ray electron boosted dark matter. Therefore, νBDM can dominantly contribute in direct detection experiments. We derive conservative but still stringent bounds and future sensitivity limits for νBDM from advanced underground dark matter and neutrino experiments such as XENON1T/nT and JUNO.

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TBD

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Stasis, Stasis, Stasis

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TBD

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TBD

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More Implications of Axion Rotations

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TBD

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Testing Majorana and Dirac Neutrino Mass Models

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In this talk, I will present Majorana neutrino mass models that yield predictions for lepton flavor violating processes that are testable in the near future. By tying the models to other observables beyond the SM, e.g., anomalies, dark matter, or baryogenesis, we obtain testable predictions for LFV that allow for falsification and goalposts for experimental sensitivities. In addition, I will briefly talk about Dirac-neutrino models that lead to testable deviations in Neff via upcoming CMB stage-IV experiments.

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Constraints on Sterile Neutrino Evidence and LSND with KARMEN1+2

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Entanglement of Astrophysical Neutrinos

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TBD

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Non-Standard Interactions in Solar Neutrinos

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TBD

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TBD

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TBD

Author: Shirley Li[1]

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Measuring the weak mixing angle at SBND

Author: Antonio Ferreira[1]

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New Limits on W_R from Meson Decays

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61

TBD

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Anomalous Tau Neutrino Appearance in Short-Baseline Neutrino Experiments

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TBD

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DAMSA, A Dark Sector Particle Search Experiment at Fermilab PIP-II LINAC

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The neutrino oscillation needs parameters to be measured precisely to provide essential information for a modification of the Standard Model. Accomplishing this novel goal in future neutrino experiments requires high flux neutrino beams and powerful combination of near and far detectors. Fermilab's PIP-II LINAC is an essential element in providing high flux protons to the Long Baseline Neutrino Facility (LBNF) for the neutrino experiments. The PIP-II LINAC can provide 2mA of proton current with 800MeV to 1GeV. The Dump produced Aboriginal Matter Search at Accelerators (DAMSA) proposes to take advantage of this large proton flux at just the right energy in search of dark sector particles (DSP). In this talk, I will discuss DAMSA experiment and its expected sensitivity reach in the Axion-Like Particle search using the high intensity PIP-II LINAC.

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An Overview of Neutrino-nucleus Interactions from Tens of MeV to a Few GeV Range: Status and Path Forward

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Current and future accelerator-based neutrino facilities utilizing intense neutrino beams and advanced neutrino detectors are focused on precisely determining neutrino oscillation properties and signals of weakly interacting Beyond the Standard Model (BSM) physics. These are subtle effects, such as extracting the CP violation phase and disentangling parameter degeneracies between oscillation effects and BSM physics, and require an unprecedented level of precision in measurements. The potential of achieving discovery-level precision and fully exploring the physics capabilities of these experiments relies greatly on the precision with which the fundamental underlying neutrino-nucleus interaction processes are known. This talk will focus on neutrinos from tens of MeV to a few GeV energies. At these energies, neutrino interactions are a non-trivial multi-scale, multi-process problem that lies in an uncharted territory that spans from low-energy nuclear physics to perturbative QCD with no known underlying unified physics. In this talk, I will present an overview of the field, discuss these challenges, highlight recent progress and present some examples of ongoing cross-community efforts tackling such a problem.

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The Sanford Underground Research Facility

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The Sanford Underground Research Facility (SURF) has been operating for more than 15 years as an international facility dedicated to advancing compelling multidisciplinary underground scientific research in rare-process physics, as well as offering research opportunities in other disciplines. SURF laboratory facilities include a Surface Campus as well as campuses at the 4850-foot level (1500 m, 4300 m.w.e.) that host a range of significant physics experiments, including the LUX-ZEPLIN (LZ) dark matter experiment and the MAJORANA DEMONSTRATOR neutrinoless double-beta decay experiment. The CASPAR nuclear astrophysics accelerator completed the first phase of operation and is planning for the second phase beginning in 2024. SURF is also home to the Long-Baseline Neutrino Facility (LBNF) that will host the international Deep Underground Neutrino Experiment (DUNE). SURF offers world-class service, including an ultra-low background environment, low-background assay capabilities, and electroformed copper is produced at the facility. SURF is preparing to increase underground laboratory space. Plans are advancing for construction of new large caverns (nominally 100m L x 20m W x 24m H) on the 4850L (1500 m, 4200 mwe) on the timeframe of next-generation experiments (~2030). SURF plans to leverage existing advisory and community committees as well as engage the underground science community to inform plans for future laboratory space.

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New Understanding of Coherence in Bragg-Primakoff Axion Detection

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Axions and axion-like pseudoscalar particles with dimension-5 couplings to photons exhibit coherent Primakoff scattering with ordered crystals at keV energy scales, making for a natural detection technique in searches for solar axions. We find that there are large suppressive corrections, potentially greater than a factor of $\mathcal{O}(10^3)$, to the coherent enhancement when taking into account absorption of the final state photon. This effect has already been accounted for in light-shining-through-wall experiments through the language of Darwin classical diffraction, but is missing from the literature in the context of solar axion searches that use a matrix element approach. We extend the treatment of the event rate with a heuristic description of absorption effects to bridge the gap between these two languages. Furthermore, we explore the Borrmann effect of anomalous absorption in lifting some of the event rate suppression by increasing the coherence length of the conversion. We study this phenomenon in Ge, NaI, and CsI crystal experiments and its impact on the the projected sensitivities of SuperCDMS, LEGEND, and SABRE to the solar axion parameter space. Lastly, we comment on the reach of multi-tonne scale crystal detectors and strategies to maximize the discovery potential of experimental efforts in this vein.

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Solar neutrinos with CEvNS and flavor-dependent radiative correction

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We examine solar neutrinos in dark matter detectors including the effects of flavor-dependent radiative corrections to the CEvNS cross section. Working within a full three-flavor framework, and including matter effects within the Sun and Earth, detectors with thresholds ⊠ 1 keV and exposures of ~ 100 ton-year could identify contributions to the cross section beyond tree level. The differences between the cross sections for the flavors, combined with the difference in fluxes, would provide a new and unique method to study the muon and tau components of the solar neutrino flux. Flavor-dependent corrections induce a small day-night asymmetry of < |3 × 10−4| in the event rate, which if ultimately accessible would provide a novel probe of flavor oscillation

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The Sanford Underground Research Facility

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The Sanford Underground Research Facility

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Student Event: A Brief History of Neutrinos

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Student Event: Introduction to DUNE

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Student Event: APS Negotiation Skills Workshop

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Student Event: How to Make a Good Poster Presentation

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DAMSA Experiment @ Fermilab PIP-II and Beyond

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