7th Symposium on Neutrinos and Dark Matter in Nuclear Physics (NDM22)

Report of Contributions

https://indico.phy.ornl.gov/e/NDM2022

Contribution ID: **1** Type: **Oral talk - Experiment**

The BeEST Experiment: A Model Independent Search for sub-MeV Neutrinos with Superconducting Quantum Sensors

Wednesday, May 18, 2022 5:00 PM (25 minutes)

The search for sterile neutrinos is among the brightest possibilities in our quest for understanding the microscopic nature of dark matter in our universe. These "mostly sterile"flavors are expected to be accompanied by heavy mass states, and thus their existence can be probed via momentum conservation with SM particles in radioactive decay. One way to observe these momentum recoil effects experimentally is through high-precision measurements of electron-capture (EC) nuclear decay, where the final state only contains the neutrino and a recoiling atom. This approach is a powerful method for BSM neutrino mass searches since it relies only on the existence of a heavy neutrino admixture to the active neutrinos - a generic feature of neutrino mass mechanisms - and not on the model-dependent details of their interactions. In this talk, we describe BeEST concept, which measures the eV-scale radiation that follows the decay of ^{7}Be ions implanted into sensitive superconducting tunnel junction (STJ) quantum sensors, and report the first results in our experimental program.

Primary author: LEACH, Kyle (Colorado School of Mines)

Presenter: LEACH, Kyle (Colorado School of Mines)

Session Classification: Parallel

Track Classification: Beyond-the-Standard-Model physics searches, sterile neutrinos, experimental anomalies

Contribution ID: **2** Type: **Oral talk - Experiment**

[REMOTE] SND@LHC experiment at CERN

Wednesday, May 18, 2022 4:10 PM (25 minutes)

SND@LHC is a compact and stand-alone experiment to perform measurements with neutrinos produced at the LHC in a hitherto unexplored pseudo-rapidity region of 7.2 < ⊠ < 8.6, complementary to all the other experiments at the LHC. The experiment is to be located 480 m downstream of IP1 in the unused TI18 tunnel. The detector is composed of a hybrid system based on an 800 kg target mass of tungsten plates, interleaved with emulsion and electronic trackers, followed downstream by a calorimeter and a muon system. The configuration allows efficiently distinguishing between all three neutrino flavours, opening a unique opportunity to probe physics of heavy flavour production at the LHC in the region that is not accessible to ATLAS, CMS and LHCb. This region is of particular interest also for future circular colliders and for predictions of very high-energy atmospheric neutrinos. The detector concept is also well suited to searching for Feebly Interacting Particles via signatures of scattering in the detector target. The first phase aims at operating the detector throughout LHC Run 3 to collect a total of 150 fb−1. The experiment was recently approved by the Research Board at CERN. A new era of collider neutrino physics is just starting.

Primary author: Dr IULIANO, Antonio (Università di Napoli Federico II and INFN)

Co-authors: SND@LHC COLLABORATION; GULER, Murat Ali (Middle East Technical University (TR))

Presenter: Dr IULIANO, Antonio (Università di Napoli Federico II and INFN)

Session Classification: Parallel

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **3** Type: **Oral talk - Experiment**

R&D and characterization of wavelength-shifting reflectors for LEGEND and for future LAr-based detectors

Friday, May 20, 2022 4:10 PM (25 minutes)

Particle detectors based on liquid nobles, such as liquid argon (LAr), often require surfaces that shift the short vacuum ultraviolet (VUV) scintillation light towards the visible range and then reflect it. For the LAr instrumentation of the LEGEND-200 neutrinoless double-beta decay experiment, the wavelength shifter tetraphenyl butadiene (TPB) was in-situ evaporated on 14m2 of the reflector Tetratex. For even larger detectors, plastic films of polyethylene naphthalate (PEN) are investigated as an option to ease scalability. We have measured the light yield from combinations of reflectors with TPB or PEN in a LAr setup. The effective light yield in the setup was determined by using a reference sample and a VUV sensitive PMT. We thus obtained the comparative efficiency of the wavelength-shifting reflective combinations, and also estimated the quantum efficiency of TPB and PEN in LAr (at 87K) for the first time. We report on these results as well as on the current R&D on wavelength-shifting reflectors for LEGEND-1000 and other future LAr-based detectors.

Primary authors: R. ARAUJO, Gabriela (University of Zurich); Prof. BAUDIS, Laura (University of Zurich)

Presenter: R. ARAUJO, Gabriela (University of Zurich)

Session Classification: Parallel

Track Classification: Instrumentation for neutrino and dark matter detection

Contribution ID: **4** Type: **Oral talk - Experiment**

Recent progress on BSM and dark matter searches in CUORE

Monday, May 16, 2022 4:50 PM (25 minutes)

The Cryogenic Underground Observatory for Rare Events (CUORE) is the first bolometric 0νββ experiment to reach the one-tonne mass scale. The detector, located underground at the Laboratori Nazionali del Gran Sasso in Italy, consists of 988 TeO2 crystals arranged in a compact cylindrical structure of 19 towers, operating at a base temperature of about 10 mK. After beginning its first physics data run in 2017, CUORE has since collected the largest amount of data ever acquired with a solid state detector and provided the most sensitive measurement of 0νββ decay in 130Te ever conducted.
The large exposure, sharp energy resolution, segmented structure and radio-pure environment make CUORE an ideal instrument for a wide array of searches for rare events and symmetry violations. New searches for low mass dark matter, solar axions, CPT and Lorenz violations, and refined measurements of the 2νββ spectrum in CUORE have the potential to provide new insight and constraints on extensions to the standard model complementary to other particle physics searches. In this talk, we discuss recent progress on BSM and dark matter searches in CUORE.

Primary author: KOWALSKI, Rebecca (Johns Hopkins)

Presenter: KOWALSKI, Rebecca (Johns Hopkins)

Session Classification: Parallel

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **5** Type: **Oral talk - Theory or phenomenology**

[REMOTE] Blazar-Boosted Dark Matter

Tuesday, May 17, 2022 2:00 PM (25 minutes)

Relativistic protons and electrons in the extremely powerful jets of blazars may boost via elastic collisions the dark matter particles in the surroundings of the source to high energies. The blazar-boosted dark matter flux at Earth may be sizeable, larger than the flux associated with the analogous process of DM boosted by galactic cosmic rays, and relevant to access direct detection for dark matter particle masses lighter than 1 GeV both with target nuclei and/or electrons. From the null detection of a signal by XENON1T, MiniBooNE, and Borexino with nulcei (by Super-K with electrons) we have derived limits on dark matter-nucleus spin-independent and spin-dependent (dark-matter-electron) scattering cross sections which, depending on the modelization of the source, improve on other currently available bounds for light DM candidates of one up to five orders of magnitude.

Primary authors: Mr GRANELLI, Alessandro (SISSA); Dr WANG, Jin-Wei (SISSA); Prof. ULLIO, Piero (SISSA)

Presenter: Mr GRANELLI, Alessandro (SISSA)

Session Classification: Parallel

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **6** Type: **Oral talk - Experiment**

[REMOTE] Axion and Dark Matter Searches Using the IsoDAR Neutrino Experiment

Friday, May 20, 2022 2:00 PM (25 minutes)

There have been several searches for new particles that can take place using experiments involving protons on target. Axions searches originated as a solution to the strong CP problem in particle physics and later a solution to explain dark matter. Theoretical bosons have also been proposed as an explanation for anomalies such as the X-17 anomaly. Using the IsoDAR neutrino experiment, we show it is possible to provide new constraints of both axions and these theoretical boson particles, and can evaluate several models describing these particles. The IsoDAR experiment has the unique advantage of having several monoenergetic photon peaks. We will also show how the IsoDAR experiment may be designed to further improve potential axion production and observation.

Primary author: WAITES, Loyd (MIT)

Presenter: WAITES, Loyd (MIT)

Session Classification: Parallel

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **7** Type: **Oral talk - Theory or phenomenology**

New Bounds on Neutrino Portals Through Upscattering Atmospheric Neutrinos

Monday, May 16, 2022 3:05 PM (25 minutes)

We consider BSM models in which neutrinos couple to Heavy Neutral Leptons (HNLs). In these models, an incoming flux of atmospheric neutrinos can scatter off of nuclei in the Earth, producing a flux of HNLs (upscattering) with energies ranging from O(10 MeV) to O(10 GeV). If an HNL decays within a neutrino detector, it can produce a visible signal, appearing as an excess of neutrino interactions. We use a Monte Carlo simulation to model this phenomenon, and compare with data from Super-Kamiokande to place leading bounds on the dipole portal for HNL masses ~10 MeV - 100 MeV and the tau mass-mixing portal for HNL masses ~15 MeV - 30 MeV. We end by estimating the upscattering signal in the next generation of neutrino experiments and using it to place projections on future bounds.

Primary authors: Mr GUSTAFSON, Robert (Virginia Tech); Dr PLESTID, Ryan (University of Kentucky; Fermi National Laboratory); Dr SHOEMAKER, Ian (Virginia Tech)

Presenter: Mr GUSTAFSON, Robert (Virginia Tech)

Session Classification: Parallel

Track Classification: Beyond-the-Standard-Model physics searches, sterile neutrinos, experimental anomalies

Contribution ID: **8** Type: **Poster**

Why not Neutrinos as the Dark Matter? A Critical Review, KATRIN and New Directions

Monday, May 16, 2022 6:00 PM (1 hour)

We challenge the traditional wisdom that cosmological (big bang relic) neutrinos can only be hot dark matter. We provide a critical review of the concepts, derivations and arguments in foundational papers, books and recent publications that led respected researchers to proclaim that "[dark matter] cannot be neutrinos". We then provide the physics resulting in relic neutrino's significant power loss from the interaction of its anomalous magnetic moment and a high-intensity primordial magnetic field resulting in subsequent condensation into Condensed Neutrino Objects (CNOs). Finally, the experimental degenerate mass bounds that would rule out condensed cosmological neutrinos as the dark matter (unless there is new physics that would require a modification to the CNO Equation of State) are provided. We conclude with a discussion on new directions for research.

Primary authors: BUETTNER, Doug (Private Researcher); MORLEY, Peter (Blue Ridge Scientific LLC)

Presenter: MORLEY, Peter (Blue Ridge Scientific LLC)

Session Classification: Poster Session

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

Closing

Saturday, May 21, 2022 1:25 PM (5 minutes)

Contribution ID: **10** Type: **Oral talk - Experiment**

[REMOTE] The NEWSdm experiment for directional dark matter searches

Tuesday, May 17, 2022 3:15 PM (25 minutes)

Despite great efforts to directly detect dark matter (DM), experiments so far have found no evidence. The sensitivity of direct detection of DM approaches the so-called neutrino floor below which it is hard to disentangle the DM candidate from the background neutrino. One of the promising methods of overcoming this barrier is to utilize the directional signature that both neutrino- and dark-matter-induced recoils possess. The nuclear emulsion technology is the most promising technique with nanometric resolution to disentangle the DM signal from the neutrino background. The NEWSdm experiment, located in the Gran Sasso underground laboratory in Italy, is based on novel nuclear emulsion acting both as the Weakly Interactive Massive Particle (WIMP) target and as the nanometric-accuracy tracking device. This would provide a powerful method of confirming the Galactic origin of the dark matter, thanks to the cutting-edge technology developed to readout sub-nanometric trajectories. In this talk we discuss the experiment design, its physics potential, the performance achieved in test beam measurements and the near-future plans. After the submission of a Letter of Intent, a new facility for emulsion handling was constructed in the Gran Sasso underground laboratory which is now under commissioning. A Conceptual Design Report is in preparation and will be submitted in 2022.

Primary authors: ALEXANDROV, Andrey (University of Naples "Federico II"); NEWSDM COLLABORATION; GULER, Murat Ali (Middle East Technical University (TR))

Presenter: ALEXANDROV, Andrey (University of Naples "Federico II")

Session Classification: Parallel

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **11** Type: **Oral talk - Theory or phenomenology**

Nuclear Physics of Neutron Star Mergers

Tuesday, May 17, 2022 8:30 AM (30 minutes)

In this talk I will review our current theoretical understanding of the dynamics of neutron star mergers, focusing on the impact of the dense matter equation of state and of neutrino radiation. I will discuss the current progress and future potential of multi-messenger observations to constrain the properties of extreme matter and the r-process nucleosynthesis yields of mergers. Finally, I will highlight pressing theory challenges.

Primary author: Prof. DAVID, Radice (Penn State)

Presenter: Prof. DAVID, Radice (Penn State)

Session Classification: Plenary

Track Classification: Neutrino astronomy and multi-messenger astrophysics

Contribution ID: **12** Type: **Oral talk - Theory or phenomenology**

Impact of COHERENT, cross section uncertainties and new interactions on the neutrino floor

Tuesday, May 17, 2022 2:50 PM (25 minutes)

A precise understanding of WIMP discovery limits is indeed required for a correct interpretation of forthcoming data from multi-ton dark matter direct detection experiments. In this talk we will reconsider the discovery limit of multi-ton direct detection dark matter experiments in the light of recent measurements of the coherent elastic neutrino-nucleus scattering process by the COHERENT experiment. We will further comment about the impact of subleading nuclear form factor uncertainties, weak mixing angle uncertainties and new physics effects on the neutrino floor. Finally, to quantify the impact of new physics effects in the neutrino background, we revisit WIMP discovery limits assuming light vector and scalar mediators as well as neutrino magnetic moments/transitions.

Primary author: DE ROMERI, Valentina (IFIC UV/CSIC)

Co-authors: ARISTIZABAL SIERRA, Diego; FLORES, Luis J.; PAPOULIAS, Dimitris K.

Presenter: DE ROMERI, Valentina (IFIC UV/CSIC)

Session Classification: Parallel

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **13** Type: **Poster**

Dark Matter, Dark Energy in the Radiation Gauge Extended Standard Model

Monday, May 16, 2022 6:00 PM (1 hour)

In 2002 Ward presented [1] a simple extension of the SM, an isospin symmetry breaking (ISB) model of spin-dependent electroweak (EW), strong and gravitational radiation gauge fields mixing with corresponding complimentary fields. The extended phenomenological model has been improved by further development identifying the complimentary fields as Yang-Mills (Y-M) fields and the use of radiation gauge theory in an extended SM approach [2]. The four radiation gauge 2x2 mixing matrices of pseudoscalar (Higgs), vector (photon), axial vector (W-Z) and tensor (graviton) gauge boson fields extracted using phenomenological data is shown to be in good agreement with values derived from the spin-dependent dynamical SM. The tensor mixing matrix analysis results in the massless graviton and a massive residual Y-M tensor gauge boson identified as dark matter (DM). Because of its mass and ordinary particle composition it weakly decays when in contact with ordinary baryonic matter as a weakly interacting massive particle (WIMP). Dark Energy (DE) is identified as the EW ISB vector interaction mixing energy which provides self-interaction and renormalization of the SM Higgs vacuum, acquiring a non-zero vacuum expectation value during EW symmetry breaking and mass generation. The WIMP-baryon reactions for two neutral current (NC) interactions, the direct (elastic) and indirect (inelastic) transitions and three indirect charge current (CC) transitions will be detailed as well as calculated spin-dependent cross-sections for each WIMP transition. Experimental results from indirect DM experiments (this symposium) and one direct DM experiment will be compared with model predictions.

[1] T. Ward, "Electroweak mixing and the generation of massive gauge bosons", in "Beyond the Desert 2002", edited by H. V. Klapdor-Kleingrothhaus, IOP publishing, Bristol and Philadelphia, 2003. Pg. 171.
[2] T. Ward, "Radiation Gauge Model in an extended SM: dark matter and dark energy". Manuscript in preparation, 2021. Also, "Search for WIMP DM Indirect Interactions using a Lead Target"T. Ward, et. al., APS National Conference, Denver, Colorado, 13-16 June 2019.

Primary author: WARD, Thomas (TechSource Incorporated/DOE-NE)

Presenter: WARD, Thomas (TechSource Incorporated/DOE-NE)

Session Classification: Poster Session

Contribution ID: **14** Type: **Oral talk - Theory or phenomenology**

[REMOTE] Neutrino mean free path in dense matter with neutrino magnetic moment and charge radius constraints and medium modifications of nucleon form factor

Friday, May 20, 2022 5:00 PM (25 minutes)

Using the relativistic mean field (RMF) model, we present the neutrino interaction with the constituents of matter, considering the neutrino form factors that are obtained from the experiments and astrophysical constraints with the medium modifications of nucleon form factors. The effect of the constraint neutrino form factors and medium modification to the neutrino mean free path will be presented. Their astrophysical implications to the cooling process in neutron star will be discussed.

Primary authors: Dr HUTAURUK, Parada Tobel Paraduan (Pukyong National University (PKNU)); Prof. ANTO , Sulaksono (Universitas Indonesia); Prof. KAZUO, Tsushima (UNICID, Sao Paulo)

Presenter: Dr HUTAURUK, Parada Tobel Paraduan (Pukyong National University (PKNU))

Session Classification: Parallel

Track Classification: Neutrino scattering in nuclear physics, astrophysics, nucleosynthesis, oscillation experiments

Contribution ID: **15** Type: **Oral talk - Experiment**

Baksan Experiment on Sterile Transitions (BEST)

Wednesday, May 18, 2022 4:35 PM (25 minutes)

The Baksan Experiment on Sterile Transitions (BEST) probes the gallium anomaly and its possible connections to oscillations between active and sterile neutrinos. Based on the Gallium-Germanium Neutrino Telescope (GGNT) technology of the SAGE experiment, the BEST setup is comprised of two zones of liquid Ga metal target to explore neutrino oscillations on the meter scale. Any deficits in the ^{71}Ge production rates in the two zones, as well as the differences between them, would be an indication of nonstandard neutrino properties at this short scale.
From July 5th to October 13th 2019, the two-zone target was exposed to a primarily monoenergetic, 3.4-MCi ^{51}Cr neutrino source 10 times for a total of 20 independent ^{71}Ge extractions from the two Ga targets. The ^{71}Ge production rates from the neutrino source were measured from July 2019 to March 2020. At the end of these measurements, the counters were filled with ^{71}Ge doped gas and calibrated during November 2020.
We report results from the BEST sterile neutrino oscillation experiment. 4σ deviations from unity were observed in the measured ratios relative to predicted values for both zones, confirming the previously reported gallium anomaly. If interpreted in the context of neutrino oscillations, the deficits give best fit oscillation parameters of $\Delta m^2 = 3.3^{+\infty}_{-2.3}$ eV^2 and $\sin^2 2\theta = 0.42^{+0.15}_{-0.17}$, consistent with $\nu_e \to \nu_s$ oscillations governed by a surprisingly large mixing angle.

Primary author: KIM, In Wook

Presenter: KIM, In Wook

Session Classification: Parallel

Track Classification: Beyond-the-Standard-Model physics searches, sterile neutrinos, experimental anomalies

Contribution ID: **16** Type: **Oral talk - Theory or phenomenology**

Plutonium-241 as a possible isotope for neutrino mass measurement and capture

Monday, May 16, 2022 3:05 PM (25 minutes)

Tritium has been the isotope of choice for measurements of the neutrino mass and planned detection of the relic neutrino background. The low mass of 3-H leads to large recoil energy of the nucleus. This has emerged as a limiting factor for both measurements. We propose to use 241-Pu as an alternative. The recoil is 80x smaller and it has similar decay energy and lifetime as 3-H. We evaluate for the first time its soft-neutrino capture cross-section and find (σv)ν = 1.52 × 10^−45 cm^2. This is 40% of the capture cross-section for tritium and makes 241Pu a promising alternative for 3-H

Primary author: DE GROOT, Nicolo (Radboud University and Nikhef)

Presenter: DE GROOT, Nicolo (Radboud University and Nikhef)

Session Classification: Parallel

Track Classification: Beta decay for neutrino mass measurements

Contribution ID: **17** Type: **Oral talk - Theory or phenomenology**

[REMOTE] Nuclear muon capture - a probe of the $0\nu\beta\beta$ decay

Friday, May 20, 2022 9:00 AM (30 minutes)

We still do not know if the neutrino is a Majorana or a Dirac particle, i.e. if the neutrino is its own antiparticle or not. Also the absolute mass scale of the neutrino is unknown, only the relative scale is known from the neutrino-oscillation experiments. These unknown features of the neutrino can be
tackled by experiments trying to detect the neutrinoless double beta ($0\nu\beta\beta$) decay. The rate of $0\nu\beta\beta$ decay can be schematically written as (here we speak about the double beta-minus decay)
\begin{equation}
%\label{eq:0vbb}
0\nu\beta\beta-\mathrm{rate} \sim \left\vert M^{(0\nu)}{\rm GTGT}\right\vert^2 =
g{{\rm A},0\nu}^4 \left\vert \sum_{J^{\pi}}
(0^+f||\mathcal{O}^{(0\nu)}{\rm GTGT}(J^{\pi})||0^+_i)\right\vert^2 \,
\end{equation}
where $M^{(0\nu)}_{\rm GTGT}$ is the double Gamow-Teller nuclear matrix element, $\mathcal{O}^{(0\nu)}_{\rm GTGT}$ denotes the transition operator mediating the $0\nu\beta\beta$ transition through the various multipole states J^π,
0^+_i denotes the initial ground state, and the final ground state is denoted by 0^+_f (for simplicity, we neglect the smaller double Fermi and tensor contributions). In the middle one has the intermediate states of multipolarity J^π, leading to the left-leg and right-leg transitions to the J^π states. Here $g^{\rm eff}_{{\rm A},0\nu}$ denotes the effective (quenched) value of the weak axial-vector coupling for $0\nu\beta\beta$ decay and it plays an extremely important role in determining the $0\nu\beta\beta$-decay rate since the rate is proportional to its $4th$ power. The amount of quenching has become an important issue in the neutrino-physics community due to its impact on the sensitivities of the present and future large-scale $0\nu\beta\beta$-decay experiments [1,2].

The ordinary muon capture (OMC) is a process where a muon μ^- is captured from the atomic s orbital by the nucleus, quite like in the case of the nuclear electron capture (EC). Since the mass of the muon is some 200 times that of the electron, in the OMC the involved momentum exchange is much larger than in the EC, of the order of 100 MeV/c. Also final states of high excitation energy and high multipolarity J^π are excited. This makes the OMC a perfect probe of the right leg of $0\nu\beta\beta$ decay in the above equation. In [3] the OMC was proposed to serve as a probe of the nuclear wave functions of the intermediate states of the $0\nu\beta\beta$ decay. Also the effective value of $g_{\rm A}$ (and the induced weak currents) can be probed at the correct momentum-exchange range. Since the proposal made in [3], OMC studies have been performed for both light and heavy nuclei, relevant for the $\beta\beta$ decays [4]. In my talk I will highlight the present status of both the experimental and theoretical studies of the OMC.

*** REFERENCES ***

[1] J. Suhonen, Impact of the quenching of $g_{\rm A}$ on the sensitivity of
$0\nu\beta\beta$ experiments, Phys. Rev. C 96 (2017) 055501.

[2] J. Suhonen, Value of the axial-vector coupling strength in β and
$\beta\beta$ decays: A review, Front. Phys. 5 (2017) 55.

[3] M. Kortelainen and J. Suhonen, Ordinary muon capture as a probe of virtual transitions of $\beta\beta$ decay, Europhys. Lett. 58 (2002) 666.

[4] H. Ejiri, J. Suhonen and K. Zuber, Neutrino-nuclear responses for astro-neutrinos, single beta decays and double beta decays, Phys. Rep. 797 (2019) 1.

Primary author: Prof. SUHONEN, Jouni (University of Jyväskylä)

Presenter: Prof. SUHONEN, Jouni (University of Jyväskylä)

Session Classification: Plenary

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **18** Type: **Oral talk - Experiment**

Design and sensitivity of nEXO's neutrinoless double beta decay search

Wednesday, May 18, 2022 2:25 PM (25 minutes)

nEXO aims to utilize 5 tonnes of enriched xenon to search for ^{136}Xe neutrinoless double beta decay, with a 90% CL half-life sensitivity of 1.35 x 10^{28} yr. To reach this half-life sensitivity, which covers the parameter space associated with the inverted neutrino mass ordering, many improvements have been made towards understanding the production and reconstruction of light and charge signals. nEXO is instrumented as a time projection chamber to detect the ionization and excitation signals from the liquid xenon medium. A substantial reduction in backgrounds is realized by the use of custom electroformed copper. To further reduce the already small background, there is ongoing R&D to actively remove radon by distillation. In this talk I shall discuss how our design choices lead to improved sensitivity.

Primary author: Dr BREUR, Sander (SLAC/Stanford)

Presenter: Dr BREUR, Sander (SLAC/Stanford)

Session Classification: Parallel

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **19** Type: **Oral talk - Experiment**

[REMOTE] Development of Ge detectors for rare-event physics searches

Friday, May 20, 2022 4:35 PM (25 minutes)

We will present the status of Ge crystal growth and detector development at University of South Dakota. The detector development including Ge internal charge amplification, Ge ionization detector in a cryo mode, thin Ge detectors, and ring-contact Ge detectors will be reported. The physics motivation, the technical challenges, and the current status of the detector development will be addressed. The correlation between different projects will also be presented.

Primary author: Prof. MEI, Dongming

Presenter: Prof. MEI, Dongming

Session Classification: Parallel

Track Classification: Instrumentation for neutrino and dark matter detection

Contribution ID: **20** Type: **Oral talk - Experiment**

Review of Neutrinoless Double Beta Decay Searches

Friday, May 20, 2022 9:30 AM (30 minutes)

The search for neutrinoless double beta decay (0nubb) is the most sensitive known way to test for the Majorana nature of the neutrino. Observation of this process would confirm the neutrino to be its own antiparticle, a property with profound implications for particle physics and cosmology. If 0nubb it exists, however, it surely has a half life in excess of 10^26 yr, and perhaps even longer than 10^28 yr if the neutrino masses are normal-ordered. Detection of 0nubb thus represents be a formidable technological challenge, requiring ton-scale or larger detectors with ultra-low levels of background. In this talk I will review the past and present and experiments engaged in the quest to discover 0nubb in isotopes including 136Xe, 76Ge, 100Mo and 130Te, and discuss prospects for discovery by future planned experiments.

Primary author: JONES, Ben (University of Texas at Arlington)

Presenter: JONES, Ben (University of Texas at Arlington)

Session Classification: Plenary

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **21** Type: **Oral talk - Experiment**

Searching for Beyond the Standard Model Physics with MicroBooNE

Monday, May 16, 2022 3:30 PM (25 minutes)

MicroBooNE is an 85-tonne active mass liquid argon time projection chamber (LArTPC) at Fermilab. It has excellent calorimetric, spatial and energy resolution and is exposed to two neutrino beams, which make it a powerful detector not just for neutrino physics, but also for Beyond the Standard Model (BSM) physics. The experiment has competitive sensitivity to heavy neutral leptons possibly present in the leptonic decay modes of kaons, and also to scalar bosons that could be produced in kaon decays in association with pions. In addition, MicroBooNE serves as a platform for prototyping searches for rare events in the future Deep Underground Neutrino Experiment (DUNE). This talk will explore the capabilities of LArTPCs for BSM physics and highlight some recent results from MicroBooNE.

Primary author: LEPETIC, Ivan (Rutgers University)

Presenter: LEPETIC, Ivan (Rutgers University)

Session Classification: Parallel

Track Classification: Beyond-the-Standard-Model physics searches, sterile neutrinos, experimental anomalies

Contribution ID: **22** Type: **Oral talk - Experiment**

[REMOTE] Dark Matter searches in the XENON experiment

Tuesday, May 17, 2022 4:35 PM (25 minutes)

Though widely accepted as the best explanation for many astrophysical and cosmological observations, Dark Matter particles have yet to be directly observed in a terrestrial detector. The XENON collaboration has long pioneered developments both in the general field of liquid xenon time projection chambers and in world leading searches for Dark Matter. Our collaboration has published world leading results from the XENON1T detector for upper limits on DM-nucleon cross-section with DM masses above 0.1 GeV, as well as other rare processes searches such as signals from solar axion and the coherent elastic scattering of solar Boron-8 neutrinos. Our next-generation detector, XENONnT is already constructed and running at the INFN Gran Sasso National Laboratory in Italy. XENONnT features a 6-tonne liquid xenon target and approximately 6 times lower background than its predecessor XENON1T. In this talk, I will review the results achieved with XENON1T, and discuss the status and discovery potential of XENONnT.

Primary author: MOSBACHER, Yossi (Weizmann Institute)

Presenter: MOSBACHER, Yossi (Weizmann Institute)

Session Classification: Parallel

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **23** Type: **Oral talk - Experiment**

LEGEND - The Large Enriched Germanium Experiment for Neutrinoless ββ Decay

Wednesday, May 18, 2022 2:50 PM (25 minutes)

The LEGEND Collaboration pursues a staged experimental program to discover the neutrinoless double-beta decay of the isotope ^{76}Ge. The discovery-oriented design of LEGEND relies on Ge detectors and liquid argon scintillation to perform an essentially background-free measurement. The first stage of the project, LEGEND-200, is currently under preparation at the Gran Sasso Laboratory in Italy and will reach within five years the sensitivity to observe the decay if its half-life is up to 10^{27} years. The second stage, LEGEND-1000, will operate a ton of Ge detectors and achieve a discovery power beyond 10^{28} years. LEGEND-1000 will not only be able to test the entire parameter space assuming the inverted neutrino mass ordering, but it will also have a high discovery potential assuming normal ordering and other new-physics scenarios.

Primary author: LI, Aobo (UNC Chapel Hill)

Co-author: AGOSTINI, matteo

Presenter: LI, Aobo (UNC Chapel Hill)

Session Classification: Parallel

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **24** Type: **Oral talk - Theory or phenomenology**

Impact of neutrino effective NSSI on sterile neutrino dark matter

Wednesday, May 18, 2022 4:10 PM (25 minutes)

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

Primary author: BENSO, Cristina (Max Planck Institute for Nuclear Physics, Heidelberg)

Co-authors: Dr RODEJOHANN, Werner (Max Planck Institute for Nuclear Physics, Heidelberg); Dr SEN, Manibrata (Max Planck Institute for Nuclear Physics, Heidelberg); Mr UJJAYINI RAMACHANDRAN, Aaroodd (RWTH Aachen)

Presenter: BENSO, Cristina (Max Planck Institute for Nuclear Physics, Heidelberg)

Session Classification: Parallel

Track Classification: Beyond-the-Standard-Model physics searches, sterile neutrinos, experimental anomalies

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

IAC Meeting

Tuesday, May 17, 2022 7:00 PM (1 hour)

Contribution ID: **27** Type: **Oral talk - Experiment**

Evidence for DM-like anomalies in neutron multiplicity spectra

Wednesday, May 18, 2022 2:00 PM (25 minutes)

Most terrestrial Dark Matter searches employ Direct Detection by looking for recoils from elastic scattering of Weakly Interacting Massive Particles. However, if the weakly interacting Dark Matter particles exist and interact with ordinary matter, such a WIMP-Baryon interaction may disintegrate both the WIMP and the baryon nucleus in the process. Such an event would send out gamma-rays and particles in all directions. A heavy target nucleus, such as Pb, would release many neutrons and protons. Part of the energetic protons would undergo (p,n) and (p,2n) reactions on the surrounding nuclei, further increasing the number of the emitted neutrons. For WIMP masses over 10 GeV/c2, one would expect emissions exceeding 100 neutrons. Although the WIMP self-annihilation cross-section must be small, such an intense neutron burst would provide a distinct signature detectable with a sensitive detector system in a low-background underground laboratory. Since the bulk of ambient neutrons come from cosmic-ray muons, it is essential to go deep underground or use a muon veto.

We have now analyzed neutron multiplicity spectra collected by three independent underground experimental setups: NEMESIS [1-3], NMDS [4], and ZEPLIN-II [5]. Interestingly, there are small but consistent anomalies in the neutron spectra from all three measurements. Adjusted for differences in neutron detection efficiencies, the positions of the anomalies agree very well. Also, the intensities match when corrected for the acquisition time and detection geometry. Therefore, while separately the three measurements are inconclusive when analyzed together, they exclude a statistical fluke to better than one in a million level.

With a five times larger target mass, six times the number of neutron detectors, dedicated lepton counters, and an improved muon veto, the proposed NEMESIS upgrade should confirm the anomalies' existence, multiplicity, and intensity above the 5σ discovery level.

[1] W.H. Trzaska et al., J. Phys.: Conf. Ser. 2156 012029. http://doi.org/10.1088/1742-6596/2156/1/012029
[2] W.H. Trzaska et al., PoS(ICRC2021)514, https://pos.sissa.it/395/514/pdf
[3] M. Kasztelan et al., PoS(ICRC2021)497, https://pos.sissa.it/395/497/pdf
[4] T.E. Ward, private communication, and AIP Conference Proceedings 842, 1103 (2006).
[5] H. M. Araujo et al., https://arxiv.org/abs/0805.3110 [hep-ex].

Primary authors: TRZASKA, Wladyslaw Henryk (University of Jyvaskyla); WARD, Thomas (TechSource Incorporated/DOE-NE); ENQVIST, Timo (University of Jyvaskyla); SZABELSKI, Jacek (NCBJ); KSZTELAN, Marcin (NCBJ); JEDRZEJCZAK, Karol (NCBJ); LOO, Kai (University of Mainz); SLUPECKI, Maciej (Helsinki Institute of Physics); USOSKIN, Ilya (Oulu University); PUPUTTI, Julia (Oulu University); BARZILOV, Alex (UNLV); JOUTESNVAARA, Jari (Oulu University); KUUSINIEMI, Pasi (University of Jyvaskyla); OSSI, Kotavaara (Oulu University); ORZECHOWSKI, Jerzy (NCBJ)

Presenter: TRZASKA, Wladyslaw Henryk (University of Jyvaskyla)

Session Classification: Parallel

Track Classification: Indirect dark-matter searches

Contribution ID: **28** Type: **Oral talk - Theory or phenomenology**

[REMOTE] Neutron Dark Decay - Theoretical and Experimental Status

Wednesday, May 18, 2022 2:25 PM (25 minutes)

The existing 4 sigma discrepancy between the neutron lifetime measurements in bottle versus beam experiments has been interpreted as a sign of neutrons decaying to dark particles with a 1% branching fraction. I will present a brief summary of this proposal, including particle physics models accommodating this scenario, as well as discuss related theoretical and experimental follow-ups. I will then elaborate on the prospects for verifying the neutron dark decay hypothesis in current and upcoming nuclear physics experiments.

Primary authors: Dr FORNAL, Bartosz (Barry University); Dr GRINSTEIN, Benjamin (University of California, San Diego)

Presenter: Dr FORNAL, Bartosz (Barry University)

Session Classification: Parallel

Track Classification: Beyond-the-Standard-Model physics searches, sterile neutrinos, experimental anomalies

Contribution ID: **29** Type: **Oral talk - Theory or phenomenology**

Collisional processes and collective oscillations of supernova neutrinos

Friday, May 20, 2022 3:15 PM (25 minutes)

Supernova simulations are yet to reliably account for collective neutrino oscillations. I'll give an overview of all the ways that collisional processes are, or have been claimed to be, relevant to oscillation outcomes. Special emphasis will be placed on collisional instabilities, a newly discovered class of phenomena that might cause flavor transformation deep inside supernovae.

Primary author: Dr JOHNS, Luke (UC Berkeley)

Presenter: Dr JOHNS, Luke (UC Berkeley)

Session Classification: Parallel

Track Classification: [Terrestrial] Neutrino flavor transformation

Contribution ID: **30** Type: **Oral talk - Experiment**

DAMIC at SNOLAB Results

Tuesday, May 17, 2022 5:00 PM (25 minutes)

The DAMIC experiment at SNOLAB uses thick, fully-depleted, scientific grade charge-coupled devices (CCDs) to search for the interactions between proposed dark matter particles in the galactic halo and the ordinary silicon atoms in the detector. DAMIC CCDs operate with an extremely low instrument noise and dark current, making them particularly sensitive to ionization signals expected from low-mass dark matter particles. This talk will focus on results from the 11 kg day exposure with traditional CCDs, including the strictest limits on the WIMP-nucleon scattering cross section for a silicon target for $m_\chi < 9$ GeV c^{-2} and an unexplained excess of ionization events below 200 $\mathrm{eV_{ee}}$. Furthermore, we will discuss the recent upgrade of the SNOLAB apparatus with two ($\sim$ 9 g each) skipper CCDs that allow for a sub-electron readout noise and therefore a lower detector threshold. We are actively acquiring data at SNOLAB with these upgraded CCDs to directly probe the previously observed excess.

Primary author: PIERS, Alexander (University of Washington)

Presenter: PIERS, Alexander (University of Washington)

Session Classification: Parallel

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **31** Type: **Poster**

Machine Learning-Powered Autonomous Data Cleaning for LEGEND-200

Monday, May 16, 2022 6:00 PM (1 hour)

The LEGEND experimental program will operate in two phases to search for neutrinoless double-beta decay ($0\nu\beta\beta$). The first (second) stage will employ 200 (1000) kg of ^{76}Ge semiconductor detectors to achieve a half-life sensitivity of 10^{27} (10^{28}) years. In this study, we present a data-driven approach to remove electronic noise, cross-talk, and non-physical events captured by ^{76}Ge detectors in LEGEND powered by a novel artificial intelligence model. We first de-noise and extract waveform shape information via a Discrete Wavelet Transform (DWT). We then utilize an unsupervised learning clustering algorithm called Affinity Propagation (AP) to obtain a representative waveform basis for a given dataset. Finally, we expand the results we obtain from AP to larger datasets with a Support Vector Machine (SVM). We demonstrate that our model is efficient at classifying events for low-background datasets obtained in early detector tests performed before the full-scale construction of LEGEND-200. This method will enable for the automatic detection and removal of non-physical events, which requires significant time and human effort in traditional data cleaning.

*This work is supported by the U.S. DOE, and the NSF, the LANL, ORNL and LBNL LDRD programs; the European ERC and Horizon programs; the German DFG, BMBF, and MPG; the Italian INFN; the Polish NCN and MNiSW; the Czech MEYS; the Slovak SRDA; the Swiss SNF; the UK STFC; the Russian RFBR ; the Canadian NSERC and CFI; the LNGS and SURF facilities.

Primary authors: LEON, Esteban (UNC Chapel Hill); GRUSZKO, Julieta (UNC Chapel Hill); LI, Aobo (UNC Chapel Hill)

Presenter: LEON, Esteban (UNC Chapel Hill)

Session Classification: Poster Session

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **32** Type: **Oral talk - Experiment**

NUCLEUS: cryogenic calorimeters to detect coherent nuclear scattering of reactor antineutrinos

Monday, May 16, 2022 4:25 PM (25 minutes)

Coherent elastic neutrino nucleus scattering (CEvNS) is a well-predicted Standard Model process only recently observed for the first time. Its precise study could reveal non-standard neutrino properties and open a window to search for physics beyond the Standard Model.
NUCLEUS is a CEvNS experiment conceived for the detection of neutrinos from nuclear reactors with unprecedented precision at recoil energies below 100 eV. Thanks to the large cross-section of CEvNS, an extremely sensitive cryogenic target of 10 g of $CaWO_4$ and Al_2O_3 crystals is sufficient to provide a detectable neutrino interaction rate.
The NUCLEUS experiment will be installed between the two 4.25 GW reactor cores of the Chooz-B nuclear power plant in France, which provide an anti-neutrino flux of $1.7 \times 10^{12} \nu/(\mathrm{s} \cdot \mathrm{cm}^2)$. At present, the experiment is under construction. The commissioning of the full apparatus is scheduled for 2022 at the Underground Laboratory of the Technical University Munich, in preparation for the move to the reactor site.

Primary author: WAGNER, Victoria (Technical University Munich)

Presenter: WAGNER, Victoria (Technical University Munich)

Session Classification: Parallel

Track Classification: Coherent elastic neutrino-nucleus scattering, nuclear excitation by neutrinos

Contribution ID: **33** Type: **Oral talk - Experiment**

Recent neutrino cross-section results from MicroBooNE

Friday, May 20, 2022 5:00 PM (25 minutes)

MicroBooNE is a liquid argon time projection chamber that operates in the Booster Neutrino Beam at Fermilab. The detector provides high-resolution imaging of neutrino interactions with a low threshold and full angular coverage. Thanks to a high event rate and several years of continuous operation, the MicroBooNE collaboration has obtained the world's largest dataset of neutrino-argon scattering events. A detailed understanding of these interactions, especially the impact of nuclear physics effects, will be critical to the success of future precision neutrino oscillation efforts, particularly the argon-based Deep Underground Neutrino Experiment (DUNE) and the Short-Baseline Neutrino (SBN) program. This talk presents the latest neutrino-argon cross-section measurements from MicroBooNE, including new measurements of inclusive electron neutrino and muon neutrino interactions, as well as exclusive final states containing one or more protons and zero pions.

Primary author: BHATTACHARYA, Meghna (Fermilab)

Co-author: GARDINER, Steven (Fermilab)

Presenter: BHATTACHARYA, Meghna (Fermilab)

Session Classification: Parallel

Track Classification: Neutrino scattering in nuclear physics, astrophysics, nucleosynthesis, oscillation experiments

Contribution ID: **34** Type: **Oral talk - Experiment**

First Results from MicroBooNE's Low Energy Excess Search

Saturday, May 21, 2022 8:30 AM (25 minutes)

The MicroBooNE collaboration recently released a series of measurements aimed at investigating the nature of the excess of low energy electromagnetic interactions observed by the MiniBooNE collaboration. In this talk, we will present the latest results from both a search of single photons in MicroBooNE, as well as a series of three independent analyses leveraging different reconstruction paradigms which look for an anomalous excess of electron neutrino events in the Fermilab Booster neutrino beam. This talk will present details of these recent results including event selection, background estimation, systematic uncertainty analysis and cross-checks to demonstrate the robustness of analysis.

Primary author: GE, Guanqun (Columbia University)

Presenters: GE, Guanqun (Columbia University); ROSS-LONERGAN, Mark (Los Alamos National Lab)

Session Classification: Parallel

Track Classification: Beyond-the-Standard-Model physics searches, sterile neutrinos, experimental anomalies

Contribution ID: **35** Type: **Oral talk - Theory or phenomenology**

Dark matter direct detection with light nuclei in a combined large-N_c and pionless effective field theory expansion

Tuesday, May 17, 2022 2:25 PM (25 minutes)

There are several complementary searches for dark matter interacting with nuclei including underground direct detection experiments that use heavy nuclei, spherical detectors that make use of light nuclei, and cosmological probes that directly constrain dark matter-proton interactions. For dark matter with a mass $m_\chi > O(1)$ GeV, i.e., a weakly interacting massive particle (WIMP), the momentum transfer in WIMP-light nucleus scattering relevant for cosmological and spherical detector scenarios is bounded from above by a few MeV and thus much less than the pion mass. Therefore, we use pionless effective field theory (EFT), a theory in which the pion has been integrated out, to describe few-nucleon systems coupled to an external WIMP current. The EFT paradigm for nuclei interacting with external currents is ideal because it is systematically improvable and nearly model-independent; however, every operator in an EFT Lagrangian comes with a coupling that must be determined from data or nonperturbative calculations. In the absence of these determinations, theoretical constraints from other sources are necessary. Here, we use the spin-flavor symmetry of the baryon sector in large-N_c quantum chromodynamics to constrain the relative sizes of the EFT couplings without recourse to data. We then explore the impact of these constraints on the WIMP-nucleus elastic scattering cross sections for several targets. Our results can interface with ongoing lattice and \textit{ab initio} calculations to guide the interpretation of experiments.

Primary author: RICHARDSON, Thomas (Duke University)

Presenter: RICHARDSON, Thomas (Duke University)

Session Classification: Parallel

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **36** Type: **Oral talk - Theory or phenomenology**

Explaining lepton-flavor non-universality and self-interacting dark matter with Lμ-Lτ

Wednesday, May 18, 2022 2:50 PM (25 minutes)

Experimental hints for lepton-flavor universality violation in the muon's magnetic moment as well as neutral- and charged-current B-meson decays require Standard-Model extensions by particles such as leptoquarks that generically lead to unacceptably fast rates of charged lepton flavor violation and proton decay. We propose a model based on a gauged U(1)(Lμ–Lτ) that eliminates all these unwanted decays by symmetry rather than finetuning and efficiently explains (g–2)_μ, R_K(∗), R_D(∗), and neutrino masses. The U(1)(Lμ–Lτ) furthermore acts as a stabilizing symmetry for dark matter and the light Z′ gauge boson mediates velocity-dependent dark-matter self-interactions that resolve the small-scale structure problems. Lastly, even the Hubble tension can be ameliorated via the light Z′ contribution to the relativistic degrees of freedom.

Primary authors: HEECK, Julian (University of Virginia); THAPA, Anil (University of Virginia)

Presenter: HEECK, Julian (University of Virginia)

Session Classification: Parallel

Track Classification: Beyond-the-Standard-Model physics searches, sterile neutrinos, experimental anomalies

Contribution ID: **37** Type: **Oral talk - Experiment**

Direct neutrino mass searches

Saturday, May 21, 2022 12:55 PM (30 minutes)

Enrico Fermi's 1934 paper, proposing the original weak-interation theory of beta decay, pointed out that the neutrino's mass would leave a signature in the endpoint of beta decay. 88 years later, the beta-decay endpoint remains our best source of neutrino-mass constraints. Better and better spectroscopy of the 18.6 keV endpoint of tritium has, for the past 30 years, provided the state-of-the-art, but other species remain interesting. In this talk, I will review recent results from KATRIN, and show plans for future experiments on 163Ho, 159Dy, and tritium, with a focus on the Project 8 cyclotron radiation electron spectroscopy project.

Primary author: MONREAL, Benjamin (Case Western Reserve University)

Presenter: MONREAL, Benjamin (Case Western Reserve University)

Session Classification: Plenary

Track Classification: Beta decay for neutrino mass measurements

Contribution ID: **38** Type: **Oral talk - Experiment**

The NEXT program for neutrinoless double beta decay searches

Tuesday, May 17, 2022 5:25 PM (25 minutes)

The NEXT experiment searches for Majorana neutrinos through neutrinoless double beta decay (0□□□) using a high pressure gaseous xenon time projection chamber. This technology offers excellent energy resolution and tracking capabilities, providing a competitive option for the tonne scale level necessary to fully cover the Majorana mass range corresponding to the inverted hierarchy of neutrino masses. Here we review the NEXT program, highlighting recent results from the NEXT-White detector at the Laboratorio Subterraneo de Canfranc and discussing the status of the NEXT-100 detector construction. We will also present the plans for future tonne-scale detectors.

Primary author: CONTRERAS, Taylor (Harvard University)

Presenter: CONTRERAS, Taylor (Harvard University)

Session Classification: Parallel

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **40** Type: **Oral talk - Experiment**

[REMOTE] Searches for exotic dark matter with the Majorana Demonstrator

Monday, May 16, 2022 5:15 PM (25 minutes)

With its excellent energy resolution and ultra-low backgrounds, the high-purity germanium detectors in the Majorana Demonstrator enable several searches for beyond the Standard Model physics ranging from the primary neutrinoless double beta decay search to searches for several classes of exotic dark matter models. Many of these dark matter models predict a peaked signature in an energy spectrum, which can be clearly resolved by germanium detectors. The Majorana detectors were operated in a low-background shield at the Sanford Underground Research Facility, and our search utilizes the 1–100 keV region of a 37 kg-year exposure collected between May 2016 and November 2019. In this talk, I will present new experimental limits for fermionic dark matter absorption, sub-GeV dark matter 3-2 body scattering, bosonic dark matter (axionlike particles and dark photons), and keV-scale sterile neutrino dark matter.

Primary author: WISEMAN, Clint (University of Washington)

Presenter: WISEMAN, Clint (University of Washington)

Session Classification: Parallel

Track Classification: Beyond-the-Standard-Model physics searches, sterile neutrinos, experimental anomalies

Contribution ID: **41** Type: **Oral talk - Theory or phenomenology**

The Nucleon Axial Form Factor from Lattice QCD and its Impact on Neutrino Oscillation Experiments

Saturday, May 21, 2022 9:45 AM (25 minutes)

Next generation neutrino oscillation experiments are transitioning from discovery to an era of precision. With this change, precise cross sections are a necessity to maximize the potential physics reach of these experiments. The nucleon axial form factor is a vital ingredient in the nucleon amplitudes used to predict quasielastic scattering, the primary signal measurement process for DUNE, yet the form factor uncertainty is constrained to 10% at best by neutrino scattering data with elementary targets. In the absence of new data on small nuclear targets, lattice QCD has the ability to compute, from first principles, the interaction of a nucleon with a weak current in the absence of a nuclear medium. In this talk, I will show the significant tension between the axial form factor obtained from elementary target data and LQCD calculations, and the implications of the form factor changes for T2K and DUNE. I will also discuss preliminary results for the Callat collaboration's calculation of the axial form factor of the nucleon.

Primary author: MEYER, Aaron (University of California, Berkeley)

Presenter: MEYER, Aaron (University of California, Berkeley)

Session Classification: Parallel

Track Classification: Neutrino scattering in nuclear physics, astrophysics, nucleosynthesis, oscillation experiments

Contribution ID: **42** Type: **Oral talk - Theory or phenomenology**

Inelastic nuclear scattering from neutrinos and dark matter

Monday, May 16, 2022 2:40 PM (25 minutes)

Neutrino sources with energy of $\mathcal{O}(10\ \text{MeV})$ are an invaluable tool for studying neutrino interactions with nuclei - previously enabling the first measurement of coherent elastic scattering. Neutrinos (and potentially dark matter) in this energy range will also excite nuclei, giving us another physics channel to study. In this work we consider the inelastic nuclear scattering of neutrinos from a variety of targets of interest. To calculate the relevant cross sections we perform large scale nuclear shell model calculations using BIGSTICK. We find that some potentially interesting signals could be observed by future experiments.

Primary author: Dr NEWSTEAD, Jayden (University of Melbourne)

Presenter: Dr NEWSTEAD, Jayden (University of Melbourne)

Session Classification: Parallel

Track Classification: Beyond-the-Standard-Model physics searches, sterile neutrinos, experimental anomalies

Contribution ID: **43** Type: **Oral talk - Experiment**

GERDA: Final Results and the Hunt for Exotic Physics

Tuesday, May 17, 2022 4:10 PM (25 minutes)

The GERDA experiment searched for the lepton-number-violating neutrinoless double-beta decay ($0\nu\beta\beta$) of ^{76}Ge. The discovery of the $0\nu\beta\beta$ decay would have profound implications for particle physics and cosmology. By operating high-purity germanium (HPGe) detectors enriched in ^{76}Ge immersed in liquid argon (LAr), the GERDA experiment achieved one of the most stringent lower limits on the half-life of the $0\nu\beta\beta$ decay of $1.8 \cdot 10^{26}$ yr at 90% C.L. (which is consistent with the sensitivity). The collaboration was able to achieve this breakthrough by reducing the background rate at the endpoint energy to $5.2 \cdot 10^{-4}$ counts/(keV kg yr). This unprecedented background index was achieved through the development of unique technologies, such as the use of the LAr's scintillation light to efficiently suppress background events that simultaneously deposit energy in the HPGe detectors and the LAr, and pulse shape discrimination that uses specific event topologies of backgrounds and signal candidates.
Due to the ultra-low background, the GERDA data is also suitable for searches for other rare events beyond $0\nu\beta\beta$ decay, such as searches for exotic physics (e.g. Majorons and Lorentz Violation) in the double-beta decay spectrum or super-WIMPs.
This talk will give an overview of the GERDA experiment, its final results, and the prospects for other physics phenomena in the GERDA data.

Primary author: KRAUSE, Patrick (Technical University of Munich)

Presenter: KRAUSE, Patrick (Technical University of Munich)

Session Classification: Parallel

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **44** Type: **Oral talk - Theory or phenomenology**

Neutrino Mass Model and Its Link to Flavor Anomalies

Wednesday, May 18, 2022 3:45 PM (25 minutes)

The Muon $g-2$ experiment at Fermilab has recently announced its measurement of the muon anomalous magnetic moment (AMM), which is in complete agreement with the long-standing tension previously reported by BNL. In addition, recent precise measurement of the fine-structure constant at Berkeley Lab shows somewhat disagreement with the electron AMM. Besides, evidence for lepton flavor universality violation in beauty-quark decays both in neutral- and charged-current transitions have been persistently observed in several experiments, and LHCb's recently updated result is in full concordance. These tantalizing flavor anomalies have discrepancies in the range $2.5\sigma - 4.2\sigma$, strongly indicating that maybe the Standard Model of particle physics is finally cracking. In this work, we propose a resolution to all these anomalies within a unified framework that is directly linked to the origin of neutrino mass. Our proposed scenario utilizes two TeV scale scalar leptoquarks to address four major flavor anomalies, while satisfying all constraints from collider searches, including the constraints from flavor physics.

Primary author: THAPA, Anil (University of Virginia)

Presenter: THAPA, Anil (University of Virginia)

Session Classification: Parallel

Track Classification: Beyond-the-Standard-Model physics searches, sterile neutrinos, experimental anomalies

Contribution ID: **45** Type: **Oral talk - Theory or phenomenology**

Probing Active-Sterile Neutrino Transition Magnetic Moments with CEvNS Photon Emission

Monday, May 16, 2022 5:15 PM (25 minutes)

In the presence of transition magnetic moments between active and sterile neutrinos, the search for a Primakoff upscattering process at Coherent Elastic Neutrino Nucleus Scattering (CEvNS) experiments provide stringent constraints on the neutrino magnetic moment. We show that a radiative upscattering process with a photon emitted in the final state can provide a novel experimental mode to probe neutrino transition magnetic moments beyond existing limits. Furthermore, the differential distributions for such a radiative mode can also potentially be sensitive to the Dirac vs. Majorana nature of the sterile state mediating the process. This can provide valuable insights into the nature and mass generation mechanism of the light active neutrinos.

Primary authors: Prof. DEPPISCH, Frank (UCL); Dr BOLTON, Patrick (SISSA Trieste); Mr FRIDELL, Kare (Munich, Tech. U.); Dr HARZ, Julia (Munich, Tech. U.); Dr HATI, Chandan (Munich, Tech. U.); Dr KULKARNI, Suchita (Graz U.)

Presenter: Prof. DEPPISCH, Frank (UCL)

Session Classification: Parallel

Track Classification: Beyond-the-Standard-Model physics searches, sterile neutrinos, experimental anomalies

Contribution ID: **46** Type: **Oral talk - Experiment**

[REMOTE] CRAB : Calibration by Recoils for Accurate Bolometry at the 100 eV scale using neutron capture

Friday, May 20, 2022 3:15 PM (25 minutes)

The development of low-threshold detectors for the study of coherent elastic neutrino-nucleus scattering and for the search for light dark matter calls for new calibration methods at sub-keV energies. We suggest this can be provided by the nuclear recoils resulting from the gamma emission following thermal neutron capture [1]. In particular, several MeV-scale single-gamma transitions induce well-defined nuclear recoil peaks in the 100 eV −1 keV range.
Using the FIFRELIN code initially designed to study fission fragment de-excitation [2], complete schemes of gamma-cascades for various isotopes can be predicted with high accuracy to determine the continuous background of nuclear recoils below the calibration peaks. The FIFRELIN high precision is achieved because the nucleus level scheme is built based on available nuclear structure information and completed if necessary with nuclear models to take into account missing information. First validations of the FIFRELIN high accuracy performed in the framework of STEREO experiment for gadolinium isotopes and with a laboratory neutron source for tungsten isotopes will be shown.
We present also a comprehensive experimental concept for the calibration of CaWO4 [3] and Ge cryogenic detectors at a research reactor emphasizing the importance of nuclear physics in this study. For CaWO4 the simulations show that two nuclear recoil peaks at 112.5 eV and 160.3 eV should be visible above background simply in the spectrum of the cryogenic detector. Then we discuss how the additional tagging for the associated gamma increases the sensitivity of the method and extends its application to a wider energy range and to other cryogenic detector materials such Ge or Si or Al.

[1] L. Thulliez, D. Lhuillier et al., Calibration of nuclear recoils at the 100 eV scale using neutron capture, Journal of Instrumentation, 16, 7 (2021)
[2] O. Litaize et al., Fission modelling with FIFRELIN, European Physical Journal A, 51, 12 (2015)
[3] G. Angloher et al. Results on MeV-scale dark matter from a gram-scale cryogenic calorimeter operated above ground: CRESST Collaboration, European Physical Journal C, 77:637, 9 2017

Primary authors: Mr THULLIEZ, Loic (IRFU, CEA, Université Paris-Saclay, 91191 Gif-sur-Yvette, France); FOR THE CRAB COLLABORATION

Presenter: Mr THULLIEZ, Loic (IRFU, CEA, Université Paris-Saclay, 91191 Gif-sur-Yvette, France)

Session Classification: Parallel

Track Classification: Instrumentation for neutrino and dark matter detection

Contribution ID: **47** Type: **Oral talk - Theory or phenomenology**

[REMOTE] Dark Matter Candidates

Wednesday, May 18, 2022 11:00 AM (30 minutes)

I will describe what the fundamental, particle nature of the dark matter could possibly consist of and I will give an overview of strategies to search for dark matter as a particle, describe a few examples of possible hints of discovery, and outline ways forward in this exciting hunt.

Primary author: Prof. PROFUMO, Stefano (UCSC)

Presenter: Prof. PROFUMO, Stefano (UCSC)

Session Classification: Plenary

Contribution ID: **48** Type: **Oral talk - Experiment**

[REMOTE] The CYGNO experiment

Wednesday, May 18, 2022 4:35 PM (25 minutes)

The CYGNO project aims to develop a gaseous high precision Time Projection Chamber with an optical readout for directional Dark Matter searches and solar neutrino spectroscopy at Laboratori Nazionali del Gran Sasso. CYGNO (a CYGNus TPC with Optical readout) is part of the CYGNUS proto-collaboration, which aims to develop, at an international level, a Galactic Nuclear Recoil Observatory, a ton scale detector with directional sensitivity.

The innovative features of CYGNO are the use of a He-CF_4 scintillating gas mixture, at atmospheric pressure and room temperature, together with a tiple GEMs amplification system optically coupled to a PMT and a sCMOS camera. Thanks to these features, it is possible to achieve 3D track reconstruction with head-tail identification, and background rejection up to energies of O(keV) to improve sensitivity on low mass WIMP energy, even overtaking the neutrino floor.

In the presentation, I will discuss the latest $R\&D$ results from the CYGNO project. I will illustrate the optical readout approach features, showing the energy threshold performances, the 3D tracking capability, the possibility of inferring the absolute Z of the particle, and the particle identification properties down to O(keV) energies. I will discuss the underground installation of the $50l$ prototype, towards the realization of the O(1)m^3 demonstrator, to show then the latest results on the internal and external radioactivity background, and thus the expected dark matter sensitivity of the $1m^3$ CYGNO demonstrator.
I will finally illustrate the synergies between CYGNO and the ERC project INITIUM, aimed at realising negative ion drift operation within the CYGNO 3D optical approach
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Samuele Torelli, on behalf of the CYGNO collaboration

Primary author: TORELLI, Samuele (Gran Sasso Science Institute)

Presenter: TORELLI, Samuele (Gran Sasso Science Institute)

Session Classification: Parallel

Track Classification: Instrumentation for neutrino and dark matter detection

Contribution ID: **49** Type: **Oral talk - Experiment**

Coherent elastic neutrino nucleus scattering: physics potential, experimental efforts and prospects for the future

Saturday, May 21, 2022 12:25 PM (30 minutes)

Coherent elastic neutrino nucleus scattering (CEνNS) means that a neutrino interacts with a nucleus as a whole, which enhances the cross section compared to other neutrino interactions. CEνNS is e.g. relevant in the modeling of Super Nova explosions and results in an inevitable background for dark matter experiments. It also opens up unique possibilities to search for BSM physics. However, the detection of the resulting recoil of the nucleus poses a huge experimental challenge.
Up to now, CEνNS has been observed by the COHERENT collaboration at a pion decay-at-rest source in CsI and Ar. At reactor-site, at lower neutrino energies many efforts are undertaken to find the respective signal. In the talk, I will give an overview on the physics potential of CEνNS, the status of the currently running experiments as well as prospects for the future.

Primary author: HAKENMUELLER, Janina (Max-Planck-institut fuer Kernphysik, Heidelberg, Germany)

Presenter: HAKENMUELLER, Janina (Max-Planck-institut fuer Kernphysik, Heidelberg, Germany)

Session Classification: Plenary

Track Classification: Coherent elastic neutrino-nucleus scattering, nuclear excitation by neutrinos

Contribution ID: **50** Type: **Oral talk - Theory or phenomenology**

Probing Neutrinoless Double Beta Decay in Multiple Isotopes

Tuesday, May 17, 2022 2:25 PM (25 minutes)

Next-generation searches for neutrinoless double beta (0νββ) decay plan to make use of several isotopes, including 76Ge, 100Mo, and 136Xe. We explore the effects of observations in multiple isotopes on the joint inference of the standard mass mechanism (light neutrino exchange) and an exotic short-range 0νββ mechanism. We also study the role that uncertainties in the nuclear matrix elements (NMEs) for 0νββ play in multi-isotope measurements. Bayesian sampling of high-dimensional likelihood distributions enables us to take into account the correlated uncertainties between NMEs of different isotopes. As NME uncertainties present a significant obstacle in interpreting searches, we project the reduction in uncertainties needed for robust inference about both standard light neutrino-exchange and exotic New Physics mechanisms for 0νββ. Our framework therefore lays the groundwork necessary to draw meaningful conclusions from combined future data, and demonstrates that both pursuing a multi-isotope experimental suite and developing understanding of the correlations between NMEs will be key for constraining theoretical models after a discovery of 0νββ.

Primary authors: VAN GOFFRIER, Graham (UCL); AGOSTINI, matteo; DEPPISCH, Frank (UCL)

Presenter: VAN GOFFRIER, Graham (UCL)

Session Classification: Parallel

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **51** Type: **Poster**

Calibrating the nEXO detector with dissolved radioisotope sources

Monday, May 16, 2022 6:00 PM (1 hour)

nEXO is a next-generation search for the neutrinoless double beta decay (0□□□) of 136Xe using a 5-tonne, monolithic liquid xenon time projection chamber (TPC). To optimize the event reconstruction and energy resolution of the TPC, calibrations are needed to map the position- and time-dependent detector response. We will describe recent work studying the feasibility of neutron-activated 127Xe as a monoenergetic source that can be dissolved directly in the liquid xenon, providing uniform calibrations of the entire detector. The 36.3 day half-life of 127Xe and its small □-value compared to that of 136Xe 0□□□ would allow a small activity to be maintained continuously in the detector during normal operations without introducing additional backgrounds, thereby enabling in-situ calibration and monitoring of the detector response. We describe an experimental demonstration of such a source in a prototype liquid xenon TPC, as well as simulations to model possible calibrations in nEXO. We show that a 127Xe source can achieve the precision required to meet nEXO's energy resolution targets, maximizing nEXO's sensitivity to neutrinoless double beta decay.

Primary author: LENARDO, Brian (Stanford University)

Presenter: LENARDO, Brian (Stanford University)

Session Classification: Poster Session

Track Classification: Instrumentation for neutrino and dark matter detection

Contribution ID: **52** Type: **Oral talk - Theory or phenomenology**

Studying dark matter with MadDM: New developments

Friday, May 20, 2022 2:25 PM (25 minutes)

MadDM is an automated numerical tool for the computation of dark-matter observables for generic new physics models based on the Monte Carlo generator MadGraph5_aMC@NLO. Notably, the code provides a comprehensive framework for the reinterpretation of direct and indirect detection searches. For instance, it allows the user to compute the fully differential nuclear recoil rates as well as the energy spectra of photons, neutrinos and charged cosmic rays for arbitrary $2 \to n$ annihilation processes. We report on the latest version enabling the automatized computation of loop-induced annihilation processes as well as ongoing developments of its capabilities for direct detection. We showcase their physics applications.

Primary author: HEISIG, Jan (Université catholique de Louvain)

Presenter: HEISIG, Jan (Université catholique de Louvain)

Session Classification: Parallel

Track Classification: Indirect dark-matter searches

Contribution ID: **53** Type: **Oral talk - Experiment**

Predicting supernovae induced event rates in KamLAND using snewpy and SNOwGLoBES

Saturday, May 21, 2022 9:20 AM (25 minutes)

Supernovae neutrinos serve as a direct probe of stellar interiors under extreme conditions. These neutrinos carry information important to open questions such as: the supernovae shock breakout mechanism, the stiffness of the nuclear equation of state, neutrino oscillation parameters and mass hierarchy, and much more. The next galactic supernova could produce hundreds to thousands of neutrino events in detectors such as KamLAND, a 1 kiloton liquid scintillator neutrino detector. We have implemented KamLAND within the SNOwGLoBES and snewpy framework and are now using it to disentangle different SN models. This work and a re-investigation of the proton elastic scattering detection channel will be presented.

Primary author: SMOLSKY, Joseph (MIT)

Presenter: SMOLSKY, Joseph (MIT)

Session Classification: Parallel

Contribution ID: **54** Type: **Poster**

Surface events pulse shape simulation for the LEGEND experiment

Monday, May 16, 2022 6:00 PM (1 hour)

The Large Enriched Germanium Experiment for Neutrinoless double-beta Decay (LEGEND) collaboration plans to search for neutrinoless double-beta ($0\nu\beta\beta$) decay in ^{76}Ge using modular arrays of germanium detectors enriched in the isotope. $0\nu\beta\beta$ candidate events happen at a single site in the germanium detector. Pulse shape simulations to model the movement of charge carriers in the detectors are key to cuts that can reject background from multi-site and surface events. Most events originating from the bulk of the detector, such as gamma-ray events, can be easily simulated by using established models of charge carriers inside the germanium. However, surface events such as those caused by alpha incidents on the detector are complex since they generate a large charge cloud, and thus their signal is influenced by effects such as diffusion and self-repulsion. Surface alpha events are also subjected to charge trapping and re-release. A minuscule amount of alpha contamination emerges from detector handling during detector fabrication, storage, and assembly. Thus, only the p+ contact and passivated surfaces of the detector are sensitive to them. While these events can be easily rejected using analysis cuts, their behavior before cuts, including their energy spectrum and their distribution on the detector surface, is difficult to model. In this poster, we describe a novel simulation of charge carriers in germanium that incorporates diffusion and self-repulsion to model surface alpha events. We show how such simulations can be sped up using parallel calculations on GPUs, and how they can be used to improve modeling of alpha backgrounds in ^{76}Ge-based $0\nu\beta\beta$ searches.

Primary author: BHIMANI, Kevin (University of North Carolina at Chapel Hill)

Presenter: BHIMANI, Kevin (University of North Carolina at Chapel Hill)

Session Classification: Poster Session

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **55** Type: **Oral talk - Experiment**

[REMOTE] Indirect Detection: Scanning the Sky for Dark Matter

Saturday, May 21, 2022 10:35 AM (30 minutes)

Dark matter particles could be unstable and decay, annihilate with each other, or subtly alter the processes within stellar interiors, imprinting characteristic signals in cosmic-ray and multi-wavelength observations. The central challenge is to distinguish these signatures from similar spectra produced by standard astrophysical processes, such as the life and death of stars and the interactions of cosmic rays with interstellar material. In this talk, I will review the current status and future potential of these indirect signatures of dark matter.

Primary author: PEREZ, Kerstin

Presenter: PEREZ, Kerstin

Session Classification: Plenary

Contribution ID: **56** Type: **Oral talk - Experiment**

Experimental study of the nucleus 136Cs with implications for liquid-xenon-based experiments in particle physics

Wednesday, May 18, 2022 3:45 PM (25 minutes)

Excited states in the isotope 136Cs are of interest both as intermediate states in the double beta decay of 136Xe and as final-state products in neutrino charged-current interactions in next-generation liquid-xenon-based particle physics experiments. In the latter case, the presence of long-lived isomeric states may enable background-free detection of solar neutrinos with sensitivity down to ~700 keV, which would enable new measurements of CNO neutrinos in upcoming experiments such as nEXO or DARWIN. Measurements of the 136Cs excited states are sparse, though recent QRPA and shell model theoretical calculations have been made. In this talk, we will describe an experimental program to characterize the nuclear levels of 136Cs and search for long-lived isomeric states. We will show new results from experiments performed at the Triangle Universities Nuclear Laboratory using (p,n) reactions on a 136Xe target.

Primary authors: LENARDO, Brian (Stanford University); BARBEAU, Phil (Duke University); RUNGE, Jay (Duke University/ TUNL); Prof. HOWELL, Calvin (Duke University and TUNL); Prof. TORNOW, Werner (Duke University and TUNL); Dr FINCH, Sean (Duke University and TUNL); Dr FRIESEN, F.Q.L. (Duke University and TUNL); MALONE, Collin (Duke University and TUNL); MANCIL, Ethan (Duke University and TUNL); IRRIG, Wolfgang (UNC Wilmington); DANIELS, Tim (UNCW); HASELSWARDT, Scott (LBNL)

Presenter: DANIELS, Tim (UNCW)

Session Classification: Parallel

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **57** Type: **Oral talk - Experiment**

The KDK experiment looking for a rare electron-capture decay

Saturday, May 21, 2022 8:30 AM (25 minutes)

Potassium-40 (40K) is a naturally-occurring radioactive isotope. It is a background in rare-event searches, plays a role in geochronology, and has a nuclear structure of interest to theorists. This radionuclide decays mainly by beta emission to calcium, and by electron-capture to an excited state of argon. The electron-capture decay of 40K directly to the ground state of argon has never been measured, and predicted intensities are highly variable (0–0.22%). This poorly understood intensity affects the precision of K-Ar dating [1] and may impact the interpretation of the DAMA claim of dark matter discovery [2]. The KDK (potassium decay) experiment is carrying out the first measurement of this electron-capture branch, using a novel setup at Oak Ridge National Labs [3]. KDK deploys a very sensitive inner detector to trigger on the ~keV radiation emitted by both forms of electron capture, surrounded by a very efficient veto to distinguish between the decays to ground state and those to the excited state. We report on our latest experimental results and the process of opening the blind data set.

[1] Carter et al, Geochronology, 2, 355–365, 2020, https://doi.org/10.5194/gchron-2-355-2020

[2] Pradler et al, Physics Letters B 720 (2013) 399–404, http://dx.doi.org/10.1016/j.physletb.2013.02.033

[3] Stukel et al, Nuclear Inst. and Methods in Physics Research, A 1012 (2021) 165593, https://doi.org/10.1016/j.nima.2021.165

Primary author: DI STEFANO, Philippe (Queen's University)

Presenter: DI STEFANO, Philippe (Queen's University)

Session Classification: Parallel

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **58** Type: **Oral talk - Theory or phenomenology**

[REMOTE] Successful nu-p process in neutrino-driven outflows in core-collapse supernovae

Friday, May 20, 2022 2:00 PM (25 minutes)

The origin of the relatively high solar system abundances of certain proton-rich isotopes in the $90 < A < 100$ mass range has been an enduring mystery in nuclear astrophysics. An attractive proposal to solve this problem is called the νp-process. This process could operate in a hot bubble of a core-collapse supernova, which is formed by a neutrino-driven outflow from the surface of the protoneutron star (PNS) after the shock is launched. However, years of detailed studies have cast doubt over the ability of this process to generate sufficient yields of ^{92,94}Mo and ^{96,98}Ru, as a well as to predict the correct abundance ratios of these isotopes to other p-nuclides. These difficulties became more dire with the recent calculations that took into account in-medium effects enhancing the rate of the triple-α reaction. Here, we revisit the problem and present explicit examples of calculations, with 13 and 18 $M_\odot$ progenitor masses, in which both the required absolute yields of the Mo and Ru p-nuclides and the observed isotopic ratios are successfully reproduced, even with the enhanced triple-α rates taken into account. The models are characterized by entropy-per-baryon values in the 80-to-90 range and by subsonic outflow profiles. Optimal conditions for the νp-process are reached at different post-bounce times for different progenitor masses, but always within the first 2-3 seconds after the start of the explosion. To obtain the required entropy values at this stage of the explosion—given the available nuclear equations of state—requires a relatively heavy PNS. This suggests that the Mo and Ru p-nuclides observed in the Solar System were made in CCSN explosions characterized by an extended accretion stage. At the same time, the νp-process yields are found to vary significantly with the PNS mass and with the outflow character.

Primary authors: PATWARDHAN, Amol (SLAC National Accelerator Laboratory); Dr FRIEDLAND, Alexander (SLAC National Accelerator Laboratory); Ms MUKHOPADHYAY, Payel (Stanford University, SLAC Natonal Accelerator Laboratory)

Presenter: PATWARDHAN, Amol (SLAC National Accelerator Laboratory)

Session Classification: Parallel

Contribution ID: **59** Type: **Oral talk - Experiment**

Noble Liquid Experiments for Neutrino and Dark Matter Interactions

Wednesday, May 18, 2022 9:00 AM (30 minutes)

Noble liquids are important target mediums for detecting neutrino interactions and searching for dark matter, thanks to their abundant scintillation and ionization yields, particle identification capabilities and availability in large quantities. Large 100-ton scale liquid argon (LAr) detectors were built and massive kiloton scale detectors are planned for detecting accelerator-produced neutrinos. Large liquid xenon (LXe) detectors with several tons of active target are currently collecting data to look for interactions of dark matter and solar neutrinos. The next generation 10-100 ton scale low background LXe and LAr detectors will have rich science opportunities for dark matter, astrophysical neutrinos and rare decay searches. Alternatively, smaller 100-kg scale noble liquid detectors with very low energy thresholds provide competitive sensitivities, compared to other target materials, for light dark matter and low energy neutrino detection. This talk will present the current status of the noble liquid experiments for dark matter and neutrino detection with the primary focus on the low background non-accelerator based experiments. We will discuss the science opportunities, recent results, challenges and novel ideas in building these experiments.

Primary author: NI, Kaixuan (UC San Diego)

Presenter: NI, Kaixuan (UC San Diego)

Session Classification: Plenary

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **60** Type: **Oral talk - Theory or phenomenology**

Neutrino Flavor Instability in Neutron Star Mergers

Friday, May 20, 2022 2:50 PM (25 minutes)

Neutrino flavor transformation is expected to significantly change the nucleosynthetic output and thus electromagnetic signature of neutron star mergers. However, merger simulations do not currently account for flavor transformation self-consistently, and there is not enough information in the common moment method for radiation transport to definitively determine the presence or results of flavor instabilities. I will present an exact method for detecting flavor instability in gray moment methods and describe the correlation between instability metrics and total flavor transformation using a suite of local (centimeter-scale) 1D flavor transformation simulations.

Primary author: RICHERS, Sherwood (UC Berkeley)

Presenter: RICHERS, Sherwood (UC Berkeley)

Session Classification: Parallel

Track Classification: Neutrino astronomy and multi-messenger astrophysics

Contribution ID: **61** Type: **Oral talk - Theory or phenomenology**

[REMOTE] Stopped-pion neutrino scattering off 127I and 133Cs using a hybrid approach of shell model and MQPM

Saturday, May 21, 2022 9:20 AM (25 minutes)

The stable iodine and caesium isotopes are the primary constituents of the CsI[Na] neutrino detector operational from 2015 to 2019 at the SNS. Theoretically computed cross sections for these nuclei are therefore of considerable interest. The goal of the research outlined in this abstract was to obtain accurate theoretical scattering cross sections along with nuclear de-excitation data for stopped pion neutrino scattering off these nuclei. The nuclear model employed was a hybrid approach where the shell model was used to model the low-lying states of the nuclei, while the microscopic quasiparticle-phonon model (MQPM) was used for states higher in energy. This led to a realistic description of the nuclear spectra up to energies relevant for the scattering reactions without sacrificing the accuracy at the low-energy end. The computed results included the scattering cross sections for all flavours of neutrinos produced in pion decay. In addition to these, nuclear de-excitation profiles were obtained by using a Monte Carlo event generator for neutrino-nucleus interactions.

Primary authors: HELLGREN, Matti (University of Jyväskylä); Dr HEDGES, Samuel; Prof. SUHONEN, Jouni (University of Jyväskylä)

Presenter: HELLGREN, Matti (University of Jyväskylä)

Session Classification: Parallel

Track Classification: Neutrino scattering in nuclear physics, astrophysics, nucleosynthesis, oscillation experiments

Contribution ID: **62** Type: **Oral talk - Theory or phenomenology**

Fast flavor neutrino oscillations with moments

Friday, May 20, 2022 2:25 PM (25 minutes)

Non-zero rest masses give rise to neutrino flavor oscillations. In addition to the vacuum potential, flavor oscillations depend on the presence of in-medium weakly-interacting particles, including other neutrinos. Within a mean-field treatment of flavor transformation in dense astrophysics environments, this neutrino-neutrino self-interaction term can produce non-linear behavior in the neutrino fields. In core-collapse supernovae and neutron star mergers, the flavor transformation depends on the number and propagation direction of the in-medium neutrinos. Specifically, if the distribution of neutrino flavor has a strong dependence on propagation direction, asymmetries may manifest and cause rapid flavor transformation. These fast-flavor oscillations are on scales much smaller than the hydrodynamical scales of the environment and present a computational challenge. The calculation of the flavor transformation is nominally a 7-dimensional problem, but can be reduced to a smaller number of dimensions by using phase-space moments of the neutrino distributions, thereby lessening the computational cost. We present results from a neutron star merger using a moment-based method for neutrino flavor transformation. Our results show promise that using a moment method could accurately describe the dynamics of fast-flavor oscillations.

Primary author: GROHS, Evan (North Carolina State University)

Co-authors: RICHERS, Sherwood (UC Berkeley); KNELLER, James (NC State University); MCLAUGHLIN, Gail (North Carolina State University)

Presenter: GROHS, Evan (North Carolina State University)

Session Classification: Parallel

Track Classification: Neutrino scattering in nuclear physics, astrophysics, nucleosynthesis, oscillation experiments

Contribution ID: **63** Type: **Oral talk - Experiment**

The Oscura experiment –searching for low-mass dark matter with a very-large array of skipper-CCDs

Wednesday, May 18, 2022 5:00 PM (25 minutes)

The Oscura experiment will deploy a very-large array of novel silicon skipper Charge Coupled Devices (CCDs) to search for low-mass dark matter (DM). Skipper-CCDs deliver sub-electron readout noise for millions of pixels, providing an ideal detector for low-threshold rare event searches for DM-electron interactions and coherent elastic neutrino-nucleus scattering. The Oscura instrument will consist of ~10 kg of skipper-CCDs and aims to achieve a total exposure of 30 kg-yr in a low background environment. Oscura will have unprecedented sensitivity to sub-GeV DM particles interacting with electrons, probing DM-electron scattering for DM masses down to ~500 keV and DM absorbed by electrons for masses down to ~1 eV. This talk will describe the Oscura experiment and the main technical challenges of the ongoing R&D effort, including engaging new foundries in the fabrication of CCD sensors, developing a cold readout solution, and understanding experimental backgrounds.

Primary author: SAFFOLD, Nathan (Fermi National Accelerator Laboratory)

Presenter: SAFFOLD, Nathan (Fermi National Accelerator Laboratory)

Session Classification: Parallel

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **64** Type: **Oral talk - Experiment**

[REMOTE] Latest news from CONNIE

Monday, May 16, 2022 3:30 PM (25 minutes)

The Coherent Neutrino-Nucleus Interaction Experiment (CONNIE) aims to detect the coherent elastic scattering of reactor antineutrinos (CEvNS) using fully depleted high-resistivity charge coupled devices (CCDs). The detector is located at a distance of 30 m from the core of the 3.8 GW Angra-2 nuclear reactor in Rio de Janeiro, Brazil. With an active mass of 50 g, a readout noise better than 2 e- RMS and using data from 2016-2018, it was possible to set a 95% C.L. upper limit on the coherent scattering rate, which was used to place stringent constraints on simplified extensions of the Standard Model with light mediators. During 2019 and 2020 new data was acquired using a hardware re-binning approach in order to achieve a better signal-to-noise ratio, lowering the energy threshold to 50 eV. In this presentation we will report on the results of the blind analysis using this data. Moreover, the experiment has recently been upgraded to host 2 skipper CCDs that are operating with a readout noise lower than 0.2 e- RMS in a very stable mode. The performance of these detectors and prospects for detecting CEvNS with the skipper technology will be also discussed.

Primary author: CERVANTES, Brenda (UNAM)

Presenter: CERVANTES, Brenda (UNAM)

Session Classification: Parallel

Track Classification: Coherent elastic neutrino-nucleus scattering, nuclear excitation by neutrinos

Contribution ID: **65** Type: **Oral talk - Experiment**

[REMOTE] Astrophysical Neutrinos: Status and Future

Saturday, May 21, 2022 11:35 AM (30 minutes)

We have entered a new era in astroparticle physics with the discovery of astrophysical, energetic neutrinos. Neutrinos, because they can travel nearly the entire universe undeflected and unimpeded, provide a new window into the non-thermal universe, one which we are only just beginning to reveal with the multi-messenger associations of neutrinos with blazers and tidal disruption events. Moreover, with this new beam of neutrinos in the TeV to PeV energy range, we can already begin to test fundamental physics in a new energy energy regime otherwise unreachable and with neutrinos propagating over cosmological distances. In parallel with these rich discoveries of high-energy neutrinos, we are pushing the energy frontier with radio experiments targeting EeV scale neutrinos. In this talk, I will review the current status of astrophysical neutrino observations and future plans with radio experiments.

Primary author: WISSEL, Stephanie (Pennsylvania State Universityty)

Presenter: WISSEL, Stephanie (Pennsylvania State Universityty)

Session Classification: Plenary

Track Classification: Neutrino astronomy and multi-messenger astrophysics

Contribution ID: **66** Type: **Oral talk - Theory or phenomenology**

[REMOTE] Double Beta Decay and New Physics

Monday, May 16, 2022 4:25 PM (25 minutes)

The observation of neutrinoless double beta decay would have far-reaching consequences for particle physics, as it would be a clear manifestation of lepton number violation and it would give a hint on the origin of neutrino masses. While searching for neutrinoless double beta decay, a significant amount of the two-neutrino double beta decay data has been collected by a number of experiments. Although these events are typically regarded and studied as the background of the neutrinoless process, I will show they can be also used to probe physics beyond the Standard Model. Specifically, I will discuss two-neutrino double beta decay contributions induced by right-handed vector currents, sterile neutrinos and neutrino self-interactions.

Primary author: GRAF, Lukas

Presenter: GRAF, Lukas

Session Classification: Parallel

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **67** Type: **Oral talk - Theory or phenomenology**

Effective Field Theories for neutrinoless double beta decay

Friday, May 20, 2022 11:30 AM (30 minutes)

Neutrinoless double beta decay (0nbb) experiments are the strongest probe of lepton number violation (LNV). While an observation of 0nbb will indicate that neutrinos are Majorana particles and will have profound implications on several open problems in particle physics, from the origin of neutrino masses to the generation of the matter-antimatter asymmetry in the Universe, the present and next generation of experiments are sensitive to a variety of LNV mechanisms, including models in which LNV arises at very high scales and scenarios with new degrees of freedom at the TeV or electroweak scales. In this talk, I will discuss how effective field theories (EFT) provide an organizational principle for a model independent interpretation of 0nbb experiments. By performing a series of matching steps in which degrees of freedom of virtualities much larger than the typical nuclear scales are progressively integrated out, EFTs allow us to systematically classify the hadronic input and to consistently construct the 0nbb transition operators induced by standard and non-standard mechanism. These steps are necessary for the calculation of 0nbb nuclear matrix elements with controlled uncertainties.

Primary author: MEREGHETTI, emanuele (LANL)

Presenter: MEREGHETTI, emanuele (LANL)

Session Classification: Plenary

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **68** Type: **Oral talk - Experiment**

Measuring long-baseline neutrino oscillations with NOvA and T2K

Monday, May 16, 2022 9:40 AM (30 minutes)

The long-baseline neutrino experiments continue to provide precision measurements of neutrino oscillation parameters by searching for the appearance of electron (anti)neutrinos and the disappearance of muon (anti)neutrinos in a beam of muon (anti)neutrinos. However, fundamental questions such as the neutrino mass ordering and the charge-parity violation in neutrinos still remain unknown.

In this talk, I will present the latest results from the NOvA and the T2K experiments, providing a snapshot of the latest accelerator-based neutrino oscillation measurements. The NOvA and T2K collaborations are also working on a combined joint-fit of their data which will not only provide a significantly tighter statistical constraint but will also be useful for breaking degeneracies in the individual measurements. I will discuss the status and plans for the joint analysis of the most recent NOvA and T2K data.

Primary author: VALLARI, Zoya

Presenter: VALLARI, Zoya

Session Classification: Plenary

Track Classification: [Terrestrial] Neutrino flavor transformation

Contribution ID: **69** Type: **Oral talk - Theory or phenomenology**

Dark Matter in the Universe

Tuesday, May 17, 2022 11:30 AM (30 minutes)

Cosmological observations conclusively tell us two things about dark matter: it composes 26% of the current energy density of the Universe, and it lies beyond the Standard Model of particle physics. These inferences rely exclusively on dark matter's gravitational influence; all other efforts to detect dark matter have only constrained its interactions with the Standard Model. Fortunately, dark matter's gravitational signatures provide clues about its origins and properties. I will summarize what astrophysics has taught us about the nature of dark matter and the current status of the cold-dark-matter paradigm. I will also discuss what we can infer about the local distribution of dark matter, which is of particular importance to terrestrial dark matter experiments.

Primary author: ERICKCEK, Adrienne (University of North Carolina at Chapel Hill)

Presenter: ERICKCEK, Adrienne (University of North Carolina at Chapel Hill)

Session Classification: Plenary

Contribution ID: **70** Type: **Oral talk - Experiment**

Status Update on the LUX-ZEPLIN Experiment

Tuesday, May 17, 2022 4:10 PM (25 minutes)

The LUX-ZEPLIN (LZ) experiment is a world-leading dark matter direct detector, which, in its full data-taking period of 1000 live days, will be sensitive to a spin-independent WIMP-nucleon cross section of 1.4 x 10^-48 cm^2 (for a 40 GeV WIMP), and will have the ability to detect other rare processes. The experiment has an active mass of 7 tonnes of xenon, is located at the Sanford Underground Research Facility in Lead, South Dakota, USA, and consists of 3 nested detectors: a dual-phase time projection chamber, surrounded by an instrumented xenon skin, which is in turn surrounded by an outer gadolinium-loaded liquid scintillator detector for rejection of neutrons and other backgrounds. Construction of the experiment was completed in 2021, and an initial calibration of the detector was completed by early 2022. In this talk, I will present an update on the status of the experiment.

Primary author: BUUCK, Micah (SLAC National Accelerator Laboratory)

Presenter: BUUCK, Micah (SLAC National Accelerator Laboratory)

Session Classification: Parallel

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **71** Type: **Oral talk - Theory or phenomenology**

[REMOTE] Lattice QCD calculations on neutrino physics and dark matter searches

Friday, May 20, 2022 8:30 AM (30 minutes)

I will give a review on recent progress of lattice QCD studies relevant for neutrino physics and dark matter searches.

Primary author: FENG, Xu

Presenter: FENG, Xu

Session Classification: Plenary

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **72** Type: **Oral talk - Experiment**

The Project 8 Neutrino Mass Experiment

Monday, May 16, 2022 2:40 PM (25 minutes)

Project 8 is a tritium endpoint neutrino mass experiment utilizing a phased program to achieve sensitivity to the full range of neutrino masses allowed by the inverted mass hierarchy. The Cyclotron Radiation Emission Spectroscopy (CRES) technique is employed to measure the differential energy spectrum of relativistic decay electrons with high precision. In this talk, I will present the recent results of Project 8, and prospects for the science program in the coming years. The recently completed Phase II extended the CRES technique to its first measurement of the continuous tritium spectrum, demonstrating control of systematics and zero-background performance. An R&D program is now undertaken to scale CRES to the larger required volumes and develop an atomic tritium source and trap.

Primary author: PETTUS, Walter (Indiana University)

Presenter: PETTUS, Walter (Indiana University)

Session Classification: Parallel

Track Classification: Beta decay for neutrino mass measurements

Contribution ID: **73** Type: **Oral talk - Theory or phenomenology**

[REMOTE] Inference of bipolar neutrino flavor oscillations near a core-collapse supernova, based on simulated measurements at Earth

Friday, May 20, 2022 4:10 PM (25 minutes)

Neutrinos in compact-object environments, such as core-collapse supernovae, can experience various kinds of collective effects in flavor space, engendered by neutrino-neutrino interactions. These include "bipolar" collective oscillations, which are exhibited by neutrino ensembles where different flavors dominate at different energies. Considering the importance of neutrinos in the dynamics and nucleosynthesis in these environments, it is desirable to ascertain whether an Earth-based detection could contain signatures of bipolar oscillations that occurred within a supernova envelope. To that end, we continue examining a cost-function formulation of statistical data assimilation (SDA) to infer solutions to a small-scale model of neutrino flavor transformation. SDA is an inference paradigm designed to optimize a model with sparse data. Our model consists of two mono-energetic neutrino beams emanating from a source and coherently interacting with each other and with a matter background, with radially-varying interaction strengths. We attempt to infer flavor transformation histories of these beams using simulated measurements of the flavor content at locations "in vacuum" (that is, far from the source), which could in principle correspond to earth-based detectors. Within the scope of this small-scale model, we found that: (i) based on such measurements, the SDA procedure is able to infer *whether* bipolar oscillations had occurred within the protoneutron star envelope, and (ii) if the measurements sample the full amplitude of the neutrino oscillations in vacuum, then the amplitude of the prior bipolar oscillations is well predicted. This result intimates that the inference paradigm can well complement numerical integration codes, via its ability to infer flavor evolution at physically inaccessible locations.

Primary authors: Prof. ARMSTRONG, Eve (New York Institute of Technology); Dr PATWARDHAN, Amol (SLAC National Accelerator Laboratory, Menlo Park, CA 94025, USA)

Presenter: Prof. ARMSTRONG, Eve (New York Institute of Technology)

Session Classification: Parallel

Track Classification: Solar and supernova neutrinos: models and detection

Contribution ID: **74** Type: **Oral talk - Theory or phenomenology**

[REMOTE] Neutrinoless Double Beta Decay via Light Neutralinos

Tuesday, May 17, 2022 2:00 PM (25 minutes)

We discuss neutrinoless double beta decay ($0\nu\beta\beta$) mediated by the lightest neutralino of arbitrary mass in the minimal supersymmetric Standard Model (MSSM) under the presence of R-parity violating trilinear interactions. In this scenario, the exchange of the lightest neutralino can result in $0\nu\beta\beta$ decay of either long-range or short-range behaviour, depending on the neutralino mass. The non-observation of $0\nu\beta\beta$ decay is then used to place constraints on the supersymmetry parameter space, compatible with constraints from collider experiments. We compare these constraints to bounds from pion decays, CKM unitarity and big bang nucleosynthesis.

Primary authors: DEV, Bhupal (Washington University in St. Louis); DEPPISCH, Frank (UCL); Dr BOLTON, Patrick (SISSA Trieste)

Presenter: DEV, Bhupal (Washington University in St. Louis)

Session Classification: Parallel

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **75** Type: **Oral talk - Theory or phenomenology**

Ab initio theory for heavy nuclei and the physics of neutrinos and dark matter

Friday, May 20, 2022 12:00 PM (30 minutes)

Breakthroughs in our treatment of the many-body problem and nuclear forces are rapidly transforming modern nuclear theory into a true first-principles discipline. This allows us to address some of the most exciting questions at the frontiers of nuclear structure and physics beyond the standard model, such as the nature of dark matter and neutrino masses, as well as searches for violations of fundamental symmetries in nature.
In this talk I will briefly outline our many-body approach, the valence-space in-medium similarity renormalization group, and how recent advances now allows us to calculate converged properties of open-shell nuclei to the 208Pb region and beyond. In particular I will focus on connections to key topics in neutrino physics, such as converged ab initio neutrinoless double-beta decay nuclear matrix elements (including the recently discovered leading-order contact term) for all major players in global searches: 76Ge, 130Te, and 136Xe. In addition, I will discuss correlations of matrix elements with those of double Gamow-Teller and double electron capture. Finally, ab initio calculations of neutrino scattering will be presented for all relevant target nuclei.

Primary author: HOLT, Jason (TRIUMF)

Presenter: HOLT, Jason (TRIUMF)

Session Classification: Plenary

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **78** Type: **Oral talk - Experiment**

Results of the MAJORANA DEMONSTRATOR's search for neutrinoless double-beta decay in ^{76}Ge

Tuesday, May 17, 2022 3:15 PM (25 minutes)

The MAJORANA DEMONSTRATOR is searching for neutrinoless double-beta decay ($0\nu\beta\beta$) in ^{76}Ge, a beyond the standard model process that would prove the neutrino is a Majorana fermion if discovered.
The experiment has completed operation of a modular array of 44 kg of high purity germanium detectors, in the p-type point contact (PPC), inverted-coaxial point-contact (ICPC), and broad energy germanium (BEGe) detector geometries.
MAJORANA operated up to 30 kg of PPC detectors and 7 kg of ICPC detectors at a time, which were enriched to 88% in ^{76}Ge.
To minimize backgrounds, the DEMONSTRATOR is constructed from low-background materials and housed inside a compact shield consisting of lead and copper at the Sanford Underground Research Facility (SURF) in Lead, SD.
The experiment has achieved a world leading energy resolution of 0.12% FWHM at 2039 keV.
Since the previous data release in 2019, MAJORANA has upgraded the electronic cables and connectors, improved its analysis routines, and successfully operated the ICPC detectors.
In March 2021, operation of the enriched detectors ended so that they could be deployed in the LEGEND-200 experiment, and the experiment continues to run with a single module with natural abundance BEGe detectors for background studies and other physics searches.
This talk will present results from the MAJORANA DEMONSTRATOR with its full exposure of 65 kg-yr from enriched detectors, and future plans for the experiment.
This material is supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, the Particle Astrophysics and Nuclear Physics Programs of the National Science Foundation, and the Sanford Underground Research Facility.

Primary author: GUINN, Ian (University of North Carolina at Chapel Hill)

Presenter: GUINN, Ian (University of North Carolina at Chapel Hill)

Session Classification: Parallel

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **79** Type: **Oral talk - Theory or phenomenology**

[REMOTE] BBN and CMB combined and separate constraints on new physics: measuring N_eff and probing its evolution

Saturday, May 21, 2022 9:45 AM (25 minutes)

Big Bang nucleosynthesis (BBN) and the cosmic microwave background (CMB) both probe physics of the early universe. BBN is the intersection of nuclear astrophysics and early-universe cosmology, explaining the cosmic origin of the lightest elements, such as ^{4}He and deuterium. Having precisely measured nuclear data as input, BBN predictions depend on the cosmic baryon-to-photon ratio $\eta = \mathrm{n_b}/\mathrm{n_\gamma}$ and the effective number of cosmic neutrino species $N_{\rm eff}$. BBN analysis has long used observed primordial abundances from astronomical observations to infer η and $N_{\rm eff}$. Crucially, both parameters are also measured independently from the CMB. Thus, the concordance between BBN and CMB determinations of these two parameters not only provides a critical test of the standard cosmology but also hints at new physics.

BBN and CMB constraints on $N_{\rm eff}$ are key concerns in the quest for Beyond-the-Standard-Model (BSM) physics. Any deviation from the Standard Model prediction would point to nonstandard cosmology and likely new physics, as a complementary cosmological approach to terrestrial particle experiments. In this talk, we show latest developments of the joint BBN+CMB constraint on the cosmological neutrinos. Moreover, we can search for any changes in η and/or $N_{\rm eff}$ between BBN and the CMB. This is a new probe: only recently BBN and the CMB independently reach levels of precision that can meaningfully reveal such changes. This open a new window to study a broad variety of BSM processes, including extra entropy and/or radiation injection between primordial nucleosynthesis and recombination.

Primary author: YEH, Tsung-Han (University of Illinois Urbana-Champaign)

Co-authors: SHELTON, Jessie (University of Illinois Urbana-Champaign); OLIVE, Keith (University of Minnesota); FIELDS, Brian (University of Illinois Urbana-Champaign)

Presenter: YEH, Tsung-Han (University of Illinois Urbana-Champaign)

Session Classification: Parallel

Track Classification: Cosmological neutrinos and detection feasibility

Contribution ID: **80** Type: **Oral talk - Experiment**

Double beta decays of ^{124}Xe and ^{136}Xe in XENON1T and XENONnT

Wednesday, May 18, 2022 2:00 PM (25 minutes)

In recent years xenon-based dark matter direct detection experiments have reached large enough target masses and low enough background levels to additionally probe rare double beta decays. Among these decays are the two-neutrino double electron capture (2νECEC) of ^{124}Xe as well as the hypothetical neutrinoless double beta decay ($0\nu\beta\beta$) of ^{136}Xe. An observation of $0\nu\beta\beta$ would provide definite proof of the neutrino's theorized Majorana nature and indicate lepton number violation. The measurement of the Standard Model 2νECEC –first detected by XENON1T in 2018 –provides nuclear structure information that could provide crucial input for the nuclear models used to interpret $0\nu\beta\beta$ experiments. This contribution will present the ^{124}Xe 2νECEC results and the search for $0\nu\beta\beta$ of ^{136}Xe in XENON1T. Moreover, the sensitivity projection for a ^{136}Xe $0\nu\beta\beta$ search in XENONnT will be discussed.

Primary author: Dr WITTWEG, Christian (University of Zurich)

Presenter: Dr WITTWEG, Christian (University of Zurich)

Session Classification: Parallel

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **81** Type: **Poster**

Measurements of the nuclear-recoil ionization yield in silicon down to 100 eV with a SuperCDMS-HVeV detector

Monday, May 16, 2022 6:00 PM (1 hour)

In experiments that look for dark matter particles or coherent neutrino nucleus scattering, we often measure the charge signal produced from the ionization of the nuclear recoil events. Nuclear recoils generate less ionization than electron recoils of the same energies, and the relative ratio, defined as the ionization yield, is crucial to calibrating the detectors. We performed a measurement of the ionization yield in silicon using a SuperCDMS HVeV detector. By using a mono-energetic, low-energy neutron beam, and observing nuclear recoils in the HVeV detector with specific scattering angles we determined the ionization yield at six different recoil energies between 100 eV and 3.9 keV. The 100 eV measurement is the lowest-energy ionization yield measurement in silicon to date. The results deviate from the Lindhard model prediction and are inconsistent with previous measurements at low energies, showing a higher than previously measured ionization yield towards lower energies.

Primary author: REN, Runze (Northwestern University)

Presenter: REN, Runze (Northwestern University)

Session Classification: Poster Session

Track Classification: Instrumentation for neutrino and dark matter detection

Contribution ID: **82** Type: **Oral talk - Theory or phenomenology**

[REMOTE] New Frontiers for Understanding Supernova Neutrinos

Tuesday, May 17, 2022 9:00 AM (30 minutes)

We can't understand core-collapse supernovae without understanding neutrinos, but we can't understand neutrinos without understanding core-collapse supernovae. What to do? I discuss new ways forward.

Primary author: BEACOM, John (OHIO STATE UNIVERSITY)

Presenter: BEACOM, John (OHIO STATE UNIVERSITY)

Session Classification: Plenary

Track Classification: Solar and supernova neutrinos: models and detection

Contribution ID: **83** Type: **Oral talk - Experiment**

[REMOTE] Nuclear matrix elements for nutrinoless double beta decays and spin dipole giant resonances studied by charge exchange nuclear reactions

Tuesday, May 17, 2022 2:50 PM (25 minutes)

Nuclear matrix elements (NME) for neutrinoless double beta decays (DBDs) are required for neutrino studies beyond the standard model, and experimental information on the NMEs are crucial for phenomenological model evaluations for the NMEs. Spin dipole (SD) components are one of major ones of the NME. The SD giant resonance energy and the SD strength in the intermediate nucleus have been studied by using charge exchange reactions, and are shown for the first time to be closely related to the pnQRPA model NMEs. On the basis of these experiments, the NME is approximately expressed as M~5.2-0.023 A with A being the mass number for DBD nuclei with A=76-136. The present work is based on recent works of refs. 1,2,3.
1. H. Ejiri, L. Jokiniemi, J. Suhonen, Phys. Rev. C. Letters, 105, L022501 2022.
2. H. Ejiri, Universe 6, 225 2020.
3. H. Ejiri, Frontiers, 9, 650421 2021.

Primary author: Prof. EJIRI, Hiroyasu (RCNP Osaka University)

Presenter: Prof. EJIRI, Hiroyasu (RCNP Osaka University)

Session Classification: Parallel

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **84** Type: **Oral talk - Experiment**

New Results from KamLAND-Zen 800 with Nearly a Ton-Year Exposure of Xe-136

Friday, May 20, 2022 11:00 AM (30 minutes)

KamLAND-Zen is searching for neutrinoless double-beta (0νββ) decay in Xe-136 using a xenon-loaded liquid scintillator. The KamLAND-Zen detector was recently upgraded with almost double the amount of xenon and an ultra-low radioactivity container. With almost 1-ton-year of ^{136}Xe exposure, we are exploring the double-beta decay parameter space corresponding to the inverted hierarchy for the first time. We have not yet observed 0νββ decay, but these results make use of novel algorithms to perform beta-gamma separation using ML and tag spallation products on day-long time scales. We obtain a lower limit for the 0νββ decay half-life of 2.3×10^{26} yr at 90% C.L., corresponding to upper limits on the effective Majorana neutrino mass of 36-156 meV using commonly adopted nuclear matrix element calculations.

Primary author: GRANT, Christopher (Boston University)

Presenter: GRANT, Christopher (Boston University)

Session Classification: Plenary

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **85** Type: **Oral talk - Experiment**

AMoRE the Korean underground neutrino and nuclear science

Tuesday, May 17, 2022 5:00 PM (25 minutes)

AMoRE (Advanced Mo-based Rare process Experiment) is an international collaboration aiming to search for the neutrinoless double beta (0n bb) decay of 100Mo using molybdate scintillating crystals with metallic magnetic calorimeters as low-temperature sensors. The data of the second phase experiment, AMoRE-I, with ~3 kg of 100Mo in the scintillating crystals, can be used to search for 0n bb decay of 100Mo to the ground and excited states of 100Ru, search for the resonance excitation of the 7Li nuclei in the Li2MoO4 crystals by hypothetical axions emitted in the de-excitation of the 7Li nuclei in the Sun. AMoRE-II that is the final phase experiment with 100 kg of 100Mo is under preparation to be installed at a new underground laboratory with deeper overburden and larger space for future experiments. The extended scale of the detector will provide further possibilities to search for symmetry violations (Lorentz, CPT), Majorons and other effects beyond the Standard Model of particles. Here, we present the current status of the AMoRE-I, preparation of the AMoRE-II, and the physics approaches using the AMoRE detector.

Primary authors: SO, Jungho (Institute for Basic Science); COLLABORATION, AMoRE

Presenter: SO, Jungho (Institute for Basic Science)

Session Classification: Parallel

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **86** Type: **Oral talk - Experiment**

Prospects for Discovery of QCD Axions

Wednesday, May 18, 2022 12:00 PM (30 minutes)

The particle nature of dark matter remains one of the great open questions in physics. The axion has had a renaissance as a dark matter candidate as theoretical studies have improved our understanding of axion cosmology and advances in quantum sensing and cryogenics have opened new opportunities for detection. In this talk, I will review the physics of the axion, its cosmology and the detection techniques that would enable a great discovery wherever the axion is hiding.

Primary author: WINSLOW, Lindley (MIT)

Presenter: WINSLOW, Lindley (MIT)

Session Classification: Plenary

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **87** Type: **Oral talk - Experiment**

[REMOTE] CRESST-III: testing light dark matter with scintillating phonon detectors

Tuesday, May 17, 2022 5:25 PM (25 minutes)

In the past decades, numerous experiments have emerged to unveil the nature of dark matter (DM), one of the most discussed open questions in modern particle physics. Among them, the CRESST-III experiment, located at LNGS, operates scintillating crystals as cryogenic phonon detectors and reaches by that one of the strongest exclusion limits on the DM-nucleon interaction cross section, in the sub-GeV DM mass region. In recent measurements, a significant low energy excess (LEE) of unknown origin appeared: a sharp rise of the event rate below 200 eV. Currently, CRESST operates detectors with targets made from multiple materials such as calcium tungstate, sapphire, silicon and lithium. This provides unique opportunities for background discrimination and studies of the LEE. In our talk, we present the technology of the experiment, its capability to test light dark matter, facts about the LEE and plans for future measurements and developments.

Primary author: WAGNER, Felix (HEPHY Vienna)

Presenter: WAGNER, Felix (HEPHY Vienna)

Session Classification: Parallel

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **88** Type: **Oral talk - Theory or phenomenology**

Neutrino oscillations as flavor isospin waves

Friday, May 20, 2022 4:35 PM (25 minutes)

Neutrinos can experience collective flavor oscillations in core-collapse supernovae (CCSNe) and binary neutron star mergers (BNSMs) where they are copiously produced. Collective oscillations can spawn spontaneously in a dense neutrino gas and propagate in the form of flavor isospin waves. Although not well understood, this novel phenomenon can have various important ramifications in the physical and chemical evolution of CCSNe and BNSMs.

Primary author: DUAN, Huaiyu (University of New Mexico)

Presenter: DUAN, Huaiyu (University of New Mexico)

Session Classification: Parallel

Track Classification: Solar and supernova neutrinos: models and detection

Contribution ID: **90** Type: **Oral talk - Theory or phenomenology**

Neutrino nucleus scattering

Monday, May 16, 2022 9:10 AM (30 minutes)

Next-generation experiments are poised to explore lepton-number violation, discern the neutrino mass hierarchy, understand the particle nature of dark matter, and answer other fundamental questions aimed at testing the validity and extent of the Standard Model. Nuclei are used for these high-precision tests of the Standard Model and for searches of physics Beyond the Standard Model. Without a thorough understanding of nuclei, including electroweak structure and reactions, we will not be able to meaningfully interpret the experimental data nor can we disentangle new physics signals from underlying nuclear effects.

In this talk, I will summarize on recent development in many-body calculations of electroweak properties of nuclei, including muon capture, and neutrino-nucleus scattering, and their connections to current experimental efforts in fundamental symmetries and neutrino physics.

Primary author: PASTORE, Saori

Presenter: PASTORE, Saori

Session Classification: Plenary

Track Classification: Neutrino scattering in nuclear physics, astrophysics, nucleosynthesis, oscillation experiments

Contribution ID: **91** Type: **Oral talk - Theory or phenomenology**

Nuclear matrix elements for neutrinoless double-beta decay

Friday, May 20, 2022 10:30 AM (30 minutes)

Neutrinoless double beta decay (0νββ-decay) is an important probe to study fundamental neutrino properties, e.g., Majorana nature, neutrino masses, CP phases, and non-standard neutrino interactions. The 0νββ-decay nuclear matrix elements (NMEs) are crucial for extracting the neutrino properties from the experimental transition rate. They can not be measured separately but must be evaluated theoretically. The present-day results obtained in a wide variety of nuclear models are discussed. The subjects of interest are many-body approximations, transition operator's form, and uncertainty in calculated NMEs. The attention is paid mainly to NMEs associated with light and heavy neutrino mass mechanisms of the 0νββ-decay. A connection between the two-neutrino double beta decay (2νββ-decay) and 0νββ-decay NMEs is addressed. An impact of the quenching of the axial-vector coupling constant on double-beta decay processes is analyzed. The related experimental and theoretical studies of single ⊠-decay, 2νββ-decay, muon capture processes, and double-charge exchange nuclear reactions are also addressed.

Primary author: Prof. ŠIMKOVIC, Fedor (Comenius University in Bratislava)

Presenter: Prof. ŠIMKOVIC, Fedor (Comenius University in Bratislava)

Session Classification: Plenary

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **92** Type: **Oral talk - Experiment**

MAGNETO-X: Fast athermal Phonon Sensing with Magnetic Quantum Sensors for DM and CEvNS Detection

Friday, May 20, 2022 2:50 PM (25 minutes)

We are developing cryogenic single-crystal detectors with magnetic quantum sensors for sub-GeV DM and CEvNS detection. Magnetic quantum sensors deposited on crystal surfaces provide fast and efficient athermal-phonon collection, which could enable phonon-pulse shape discrimination (PPSD) of electron and nuclear recoil (ER and NR) signals for active background rejection in DM search and CEvNS detection experiments. We are optimizing athermal-phonon collection speed and efficiency using cm-scale sapphire crystals, and have obtained approximately 50% efficiency for athermal-phonon collection. The magnetic sensor's response time was in an order of 1-microsecond and was sufficient to resolve different athermal-phonon arrival times of ER and NR signals for PPSD. The preliminary results with sapphire crystals and future test plans using scintillating crystals and semiconducting crystals for PPSD will be presented.

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. This work was funded by the Laboratory Directed Research and Development program of Lawrence Livermore National Laboratory (22-FS-011).

Primary authors: KIM, Geon-Bo (LLNL); Prof. KAGAN, Harris (Ohio State University); Prof. BOYD, S.T.P. (University of New Mexico)

Presenter: KIM, Geon-Bo (LLNL)

Session Classification: Parallel

Track Classification: Instrumentation for neutrino and dark matter detection

Contribution ID: **93** Type: **Poster**

The First Machine Learning Analysis for Majorana Demonstrator Experiment

Monday, May 16, 2022 6:00 PM (1 hour)

Neutrinoless Double Beta Decay($0\nu\beta\beta$) is one of the major research interests in neutrino physics. The discovery of $0\nu\beta\beta$ would answer persistent puzzles in the standard model. In the search of $0\nu\beta\beta$, The Majorana Demonstrator experiment retains the best energy resolution and one of the lowest backgrounds at the region of interest. Data is collected from 63.9kg of enriched and natural Germanium-76 crystals operating as detector arrays of both p-type point-contact detectors and inverted-coaxial point-contact detectors. Several pulse shape parameters have been developed to reject backgrounds. To collectively analyze those pulse shape parameters, we developed a fully interpretable boosted decision tree (BDT) model that has the potential to outperform the traditional selection criteria. By interpreting the BDT, we find that it uses parameter correlation to identify known background event categories that have required supplementary cuts in the traditional analysis. We demonstrated that the BDT analysis and traditional analysis benefit each other in a reciprocal way. This material is supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, the Particle Astrophysics and Nuclear Physics Programs of the National Science Foundation, and the Sanford Underground Research Facility.

Primary author: LI, Aobo (UNC Chapel Hill)

Presenter: LI, Aobo (UNC Chapel Hill)

Session Classification: Poster Session

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **94** Type: **Oral talk - Experiment**

Status and Prospects of Cosmology Surveys

Tuesday, May 17, 2022 10:30 AM (30 minutes)

The fundamental nature of dark matter and neutrinos affect our Universe in ways that we can probe through its evolution over cosmic scales of distance and time. From precision measurements of the Cosmic Microwave Background radiation at the start of the 21st century through to the first sets of precision weak lensing measurements almost twenty years later, we are pursuing a rapidly expanding explosion of cosmological information that will culminate in the 2020s with the start of several revolutionary observatories on the ground and in space. In almost every sense, these experiments will increase our capabilities a hundred-fold. Spanning spectrography and photometry, wavelengths of a meter to a micron, and times from the beginning of the Universe to today, I will summarize where we stand with cosmological surveys and where we're rapidly accelerating to.

Primary author: Prof. TROXEL, Michael (Duke University)

Presenter: Prof. TROXEL, Michael (Duke University)

Session Classification: Plenary

Contribution ID: **95** Type: **Oral talk - Experiment**

Neutrinoless Double Beta Decay in the SNO+ Experiment

Tuesday, May 17, 2022 4:35 PM (25 minutes)

SNO+ is a large-scale multi-purpose neutrino detector, located 2 km underground at SNOLAB, Canada. The primary aim of the experiment is to search for neutrinoless double-beta decay ($0\nu\beta\beta$), along with a variety of other physics programs including detection of solar, reactor, and supernova neutrinos, measuring the geoneutrino flux, and searching for invisible nucleon decay. The experiment has completed data taking during a commissioning phase filled with water and is now fully filled with 780 tonnes of liquid scintillator. Finally, the scintillator will be loaded with several tonnes of tellurium to facilitate the $0\nu\beta\beta$ search. This talk will present recent results, including the first low energy event by event direction reconstruction in liquid scintillation, as well as the preparations for $0\nu\beta\beta$ and the projected sensitivities to half-life limits and effective Majorana mass measurements.

Primary author: PARKER, William (Oxford University)

Presenter: PARKER, William (Oxford University)

Session Classification: Parallel

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **96** Type: **Poster**

Modeling Backgrounds for the MAJORANA DEMONSTRATOR

Monday, May 16, 2022 6:00 PM (1 hour)

The MAJORANA DEMONSTRATOR is a neutrinoless double beta decay ($0\nu\beta\beta$) experiment consisting of ~30 kg of germanium detectors enriched to 88% in ^{76}Ge and ~14 kg of natural germanium detectors. The detectors are divided between two cryostats and surrounded by a graded passive shield. The DEMONSTRATOR achieved one of the lowest background rates in the region of the $0\nu\beta\beta$ Q-value, 11.9 $\pm$ 2.0 cts/(FWHM t y) from the low-background configuration of the initial 26 kg-yr exposure. Nevertheless this background rate is a factor of four higher than the projected background rate based on component assays. This discrepancy arises from an excess of events from the ^{232}Th decay chain. Background model fits using two different statistical approaches aim to understand this deviation from assay-based projections, potentially determine the source(s) of observed backgrounds, and allow a precision measurement of the two-neutrino double-beta decay half-life. These fits, combined with supplemental analyses, indicate the origin of the ^{232}Th excess is not from a near-detector component, which has informed design decisions for the next-generation LEGEND experiment. Recent findings have narrowed the suspected locations for the excess activity, motivating the ongoing simulation and assay campaign.

Primary authors: REINE, Anna (University of North Carolina at Chapel Hill); HAUFE, Christopher (University of North Carolina at Chapel Hill)

Presenters: REINE, Anna (University of North Carolina at Chapel Hill); HAUFE, Christopher (University of North Carolina at Chapel Hill)

Session Classification: Poster Session

Track Classification: Double beta decay: experiments and nuclear matrix elements

Contribution ID: **99** Type: **Oral talk - Theory or phenomenology**

Neutrino signals and/or backgrounds in dark matter detectors

Wednesday, May 18, 2022 8:30 AM (30 minutes)

Dark matter detection experiments are closing in on sensitivity to astrophysical neutrinos from the Sun and the atmosphere. I will discuss the prospects for detecting these neutrinos, and for using this detection to extract information on the properties of neutrinos and their sources. I will discuss methods that can be used to differentiate neutrino from dark matter signals.

Primary author: STRIGARI, Louis (Texas A&M)

Presenter: STRIGARI, Louis (Texas A&M)

Session Classification: Plenary

Contribution ID: **100** Type: **Oral talk - Theory or phenomenology**

Chiral effective field theory for dark matter direct detection

Wednesday, May 18, 2022 9:30 AM (30 minutes)

We discuss the application of chiral effective field theory (EFT) to the calculation of nuclear responses for the scattering of weakly interacting massive particles (WIMPs) off nuclear targets. A consistent interpretation of the limits set by current and future direct-detection searches in terms of the WIMP parameter space requires the use of a series of EFTs to bridge the gap between the scales of physics beyond the standard model and the nuclear scales to which the experimental searches are sensitive. Chiral EFT incorporates the QCD constraints in the nucleon matrix elements and the nuclear responses, and thus provides the necessary formalism to describe the hadronic and nuclear aspects of direct detection experiments.

We review the current status of calculations for WIMP interactions with nuclei based in chiral EFT. This includes large-scale calculations for spin-dependent WIMP scattering for all nuclei relevant for dark matter direct detection. For spin-dependent interactions, the inclusion of WIMPs coupling to two nucleons through two-body currents has especially improved the sensitivity of experiments to the paired species, e.g., for the spin-dependent WIMP-proton cross section limits for xenon detectors. Moreover, we have developed a general framework for WIMPs coupling to nuclei, focusing on all leading spin-independent nuclear responses that can be coherently enhanced with the number of nucleons. In fact, after the standard spin-independent WIMP-nucleon interactions, the next largest response results from the coupling of WIMPs to pions in nuclei. This led to the first limits for the WIMP-pion coupling from the XENON1T experiment. We also discuss insights provided by chiral EFT for the analysis of the experiments and connections of the nuclear responses to coherent elastic neutrino-nucleus scattering.

Primary author: SCHWENK, Achim (TU Darmstadt)

Presenter: SCHWENK, Achim (TU Darmstadt)

Session Classification: Plenary

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **101** Type: **Oral talk - Experiment**

Solar Neutrino Physics with Borexino

Saturday, May 21, 2022 8:55 AM (25 minutes)

Solar neutrinos are unique probes for studying the Sun. The Borexino experiment uses organic liquid scintillator as detection material. Thanks to the reached unprecedented levels of radio-purity, Borexino measured neutrinos from the pp chain and CNO cycle. Currently, the recent solar model predictions prefer low metal abundances which are, however, in tension with helioseismology data preferring the older solar model predictions with higher metal abundances. This is known as the solar metallicity problem. The measurements of solar neutrino fluxes by Borexino can be used to test the Standard Solar Model predictions. Among the measurements, those of CNO neutrinos are of particular interest. The CNO neutrino flux depends directly on the carbon and nitrogen abundances, and, thus can be used to probe the metallicity of the Sun directly. In this talk, I will review the measurements of pp-chain and CNO-cycle solar neutrinos by Borexino, and discuss their implications on solar physics.

Primary author: DING, Xuefeng

Presenter: DING, Xuefeng

Session Classification: Parallel

Track Classification: Solar and supernova neutrinos: models and detection

Contribution ID: **103** Type: **Oral talk - Theory or phenomenology**

Sterile Neutrinos

Monday, May 16, 2022 12:10 PM (30 minutes)

I provide an overview of sterile neutrinos, including motivations - why do we think they exist and what are they good for - and current constraints/hints.

Primary author: DE GOUVEA, Andre (Northwestern University)

Presenter: DE GOUVEA, Andre (Northwestern University)

Session Classification: Plenary

Contribution ID: **104** Type: **Oral talk - Experiment**

Long-baseline neutrino oscillation experiments

Monday, May 16, 2022 10:10 AM (30 minutes)

Long-baseline neutrino oscillation experiments are sensitive to the parameters governing nu_1-nu_3 and nu_2-nu_3 mixing, including the neutrino mass ordering and a potentially CP violating phase in the PMNS matrix. These measurements are of particular interest because observation of CP violation in the lepton sector could be an important step in understanding the origin of the baryon asymmetry of the universe, and precise knowledge of oscillation parameters will contribute to understanding if there are new symmetries in the neutrino sector, whether there is a relationship between the generational structure of quarks and leptons, and whether the three-neutrino picture of neutrino oscillation is complete. In this presentation, status, plans, and outlook for current and future long-baseline oscillation experiments will be surveyed, with a focus on complementarity and expected sensitivity. Other physics topics accessible with long-baseline neutrino experiments will also be briefly discussed.

Primary author: WORCESTER, Elizabeth (Brookhaven National Lab)

Presenter: WORCESTER, Elizabeth (Brookhaven National Lab)

Session Classification: Plenary

Track Classification: [Terrestrial] Neutrino flavor transformation

Contribution ID: **105** Type: **Oral talk - Experiment**

Next-Generation CMB Experiments

Tuesday, May 17, 2022 11:00 AM (30 minutes)

The Cosmic Microwave Background (CMB) is a powerful tool for understanding cosmology and particle physics. At large angular scales, the CMB images the primordial universe providing a window into physics that preceded the hot radiation-dominated era. The CMB also images acoustic oscillations in our early universe exquisitely tracing our thermal history and the corresponding evolution of our universe's energy composition. The CMB is also sensitive to physics of the "late" universe through secondary CMB anisotropies such as weak gravitational lensing and scattering. These mechanisms provide tools for the CMB to constrain fundamental physics including inflation, neutrinos, light relic particles, dark matter, and dark energy. In this talk, I will provide an overview of near-term CMB experiments with a particular emphasis on ground-based measurements including the upcoming CMB-S4 project, a community-wide effort to extend our CMB capabilities by an order of magnitude over projects that are currently observing or under construction. I will conclude with some thoughts on future opportunities for mm-wave cosmological surveys and technical connections to low energy dark matter and neutrino experiments.

Primary author: CHANG, Clarence (Argonne National Lab & the University of Chicago)

Presenter: CHANG, Clarence (Argonne National Lab & the University of Chicago)

Session Classification: Plenary

Contribution ID: **108** Type: **Oral talk - Experiment**

Progress in Solid State Dark Matter Detection

Wednesday, May 18, 2022 10:30 AM (30 minutes)

The dark matter direct detection landscape continues to shift, as solid-state detectors become ever more sensitive to minute depositions of energy. New synergies with quantum information science have broadened interest in the detectors themselves and created new collaborations. The next generation of solid-state detectors are forecasted to probe many square decades of unexplored dark matter parameter space below 5 GeV, covering over 6 decades in mass: 1-100 eV for dark photons and axion-like particles, 1-100 MeV for dark-photon-coupled light dark matter, and 0.05-5 GeV for nucleon-coupled dark matter. Some proposed experiments can reach the neutrino fog in the 0.5-5 GeV mass range and new materials offer the promise of directional sensitivity that can distinguish the dark matter from background neutrinos.

Primary author: CUSHMAN, Priscilla (University of Minnesota)

Presenter: CUSHMAN, Priscilla (University of Minnesota)

Session Classification: Plenary

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **109** Type: **Oral talk - Experiment**

[REMOTE] Light Dark Matter Searches at Accelerators

Saturday, May 21, 2022 11:05 AM (30 minutes)

Theories of light sub-GeV dark matter and dark sectors are well-motivated and are being pursued on a variety of experimental fronts. Accelerator experiments utilizing intense and energetic proton or lepton beams play a crucial role in this effort. In this talk, I will highlight the exciting opportunities to search for dark matter using fixed target and collider experiments, including experiments designed to study neutrino interactions and oscillations.

Primary author: BATELL, Brian (University of Pittsburgh)

Presenter: BATELL, Brian (University of Pittsburgh)

Session Classification: Plenary

Contribution ID: **110** Type: **Oral talk - Experiment**

[REMOTE] MeV-Scale Dark Matter Searches

Tuesday, May 17, 2022 12:00 PM (30 minutes)

In this talk I will review the current experimental status of dark matter searches in the MeV scale. Will describe the existing technologies probing this regime using electron recoil and discuss prospects for future projects.

Primary author: ESTRADA, juan (Fermilab)

Presenter: ESTRADA, juan (Fermilab)

Session Classification: Plenary

Contribution ID: **111** Type: **not specified**

[REMOTE] Flavor Transformation

Tuesday, May 17, 2022 9:30 AM (30 minutes)

TBD

Primary author: FULLER, George

Presenter: FULLER, George

Session Classification: Plenary

Contribution ID: **112** Type: **Oral talk - Experiment**

[REMOTE] The Jiangmen Underground Neutrino Observatory Experiment

Monday, May 16, 2022 11:10 AM (30 minutes)

Jiangmen Underground Neutrino Observatory (JUNO) is a medium-baseline reactor neutrino experiment currently under construction in Jiangmen City in South China. The central detector (CD) is a 20 kton liquid scintillator (LS) neutrino target housed in an acrylic sphere of 35.4m in diameter, submersed in a cylindrical water Cherenkov veto detector of 43.5m in diameter and depth. The JUNO experimental hall is 52.5km away from both the Yangjiang and Taishan nuclear power plants and ~700m underground. JUNO's CD will be equipped with 17,612 20-in photomultiplier tubes (PMTs) and 25,600 3-in PMTs, providing photocathode coverage of 75.2% and 2.7%, respectively. The water Cherenkov veto detector is equipped with 2,400 20-in PMTs. CD's energy resolution is expected to be better than 3% at 1MeV and to have an absolute energy scale uncertainty better than 1% over the whole reactor antineutrino energy range. With such an unprecedented target mass and excellent energy resolution for a LS detector, JUNO's main physics goals are to resolve neutrino mass ordering (NMO) and to measure 3 neutrino oscillation parameters with high precision. With 6 years of data, NMO is expected to be determined with a ~3σ significance and sub-half-percent precisions for 3 oscillation parameters: $\sin^2\theta_{12}$, Δm^2_{21}, and $|\Delta m^2_{32}|$. In addition to the main 20 kton LS detector, the JUNO experiment also has a satellite detector, Taishan Antineutrino Observatory (JUNO-TAO), which is ~30m away from the Taishan number one reactor. JUNO-TAO's energy resolution is expected to be better than 2% at 1 MeV. Besides its main goals in neutrino oscillation physics, the JUNO experiment is also expected to have great physics reach with solar neutrinos, supernova neutrinos, geoneutrinos, atmospheric neutrinos, and searches for physics beyond the Standard Model such as nucleon decay. The detector construction is expected to be completed in 2023. In this talk, we will present the design of the JUNO detector system, its status, and the expected physics reach.

Primary author: WANG, Wei (Sun Yat-sen University)

Presenter: WANG, Wei (Sun Yat-sen University)

Session Classification: Plenary

Contribution ID: **113** Type: **not specified**

Short Baseline Overview

Monday, May 16, 2022 11:40 AM (30 minutes)

TBD

Primary author: WONGJIRAD, Taritree

Presenter: WONGJIRAD, Taritree

Session Classification: Plenary

Contribution ID: **114** Type: **not specified**

Sterile Overview

Monday, May 16, 2022 12:40 PM (30 minutes)

TBD

Primary author: LITTLEJOHN, Bryce

Presenter: LITTLEJOHN, Bryce

Session Classification: Plenary

Contribution ID: **115** Type: **not specified**

[REMOTE] Astrophysical axions

Wednesday, May 18, 2022 11:30 AM (30 minutes)

Primary author: SAFDI, Ben

Presenter: SAFDI, Ben

Session Classification: Plenary

Contribution ID: **116** Type: **not specified**

Opening

Monday, May 16, 2022 9:00 AM (10 minutes)

Presenter: ENGEL, Jonathan (University of North Carolina)

Contribution ID: **117** Type: **Oral talk - Experiment**

Studies of Neutrinos and Dark Matter with the COHERENT experiment

Monday, May 16, 2022 4:50 PM (25 minutes)

The COHERENT collaboration operates an array of detectors at the ORNL Spallation Neutron Source (SNS) to measure coherent elastic neutrino nucleus scattering (CEvNS) and to search for dark matter. The 1.4 MW SNS pulsed proton beam produces an intense neutrino flux and may be producing dark matter particles. Our low-energy-threshould detectors sited in the low-background "Neutrino Alley" near this source are producing world-leading sensitivity for these measurements. We observed the first events from CEvNS in 2017 with a cesium-iodide scintillation detector and have new results from an expanded data set. We followed up with a measurement on a lighter argon nucleus, thus confirming the CEvNS hypothesis, that we published in 2020. These data sets can also be used to search for dark matter as predicted in a class of portal-particle dark matter theories and our recent cesium-iodide results elimate some parameter-space required to explain cosmologically observed dark-matter. These measurements will be presented along with plans for further extending our physics reach with new detectors in the near future.

Primary author: TAYLOE, Rex (Indiana University)

Presenter: TAYLOE, Rex (Indiana University)

Session Classification: Parallel

Track Classification: Coherent elastic neutrino-nucleus scattering, nuclear excitation by neutrinos

Contribution ID: **118** Type: **Oral talk - Experiment**

Status and perspectives of the DarkSide experimental program

Saturday, May 21, 2022 8:55 AM (25 minutes)

A vast body of astrophysical and cosmological observations point at the existence of an abundant form of matter interacting almost exclusively through gravity. A leading dark matter candidate is a weakly interacting massive particle, or WIMP, a thermal relic of the Big Bang, which has a sub-electroweak-scale self-annihilation cross section and a mass in the TeV/c^2-range. The motion of galactic halo WIMPs relative to a detector on Earth could result in WIMP-nucleus elastic collisions detectable by a low-background, low-energy-threshold detector capable of unambiguously identifying a small number of nuclear recoils from WIMP collisions over the course of a very large exposure. Thanks to its excellent ionization response and unique scintillation light emission characteristics, liquid argon (LAr) can provide excellent sensitivity for WIMP nuclear collisions and strong background suppression.
Building upon its vast experience with liquid argon detectors, the DarkSide Collaboration, now Global Argon Dark Matter Collaboration, is building a new generation experiment featuring 50 tonnes of liquid argon as target for DM interactions hosted in a dual-phase time projection chamber (TPC). This experiment, DarkSide-20k, extends the cross section vs. mass range sensitivity in the search for dark matter to 4.6x10^{-48} cm^2 for a 90% C.L. exclusion and 1.5x10^{-47} cm^2 at a 5 sigma discovery significance for a 1 TeV/c^2 WIMP after a 10 yr run, beyond any current or presently funded experiment. Several essential elements allow DarkSide-20k to achieve this goal. These are: low argon target activity; use of the scintillation light signal for energy measurement and pulse shape discrimination against backgrounds; event position reconstruction using the ionization signal; an active neutron veto surrounding the LAr TPC; and excellent shielding from background radiation by an active muon veto. These techniques are implemented by a combination of new and proven technologies, including low-radioactivity argon from underground sources, SiPM-based cryogenic photosensors, a ProtoDUNE-like cryostat filled with atmospheric argon, and a LAr TPC constructed from low-background acrylic.

Primary author: SAVARESE, Claudio (Princeton University)

Presenter: SAVARESE, Claudio (Princeton University)

Session Classification: Parallel

Track Classification: Direct dark-matter searches with atomic and nuclear targets

Contribution ID: **119** Type: **not specified**

Conference Check-in