NTN Workshop on Neutrino Non-Standard Interactions

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Book of Abstracts

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Light Dark Matter with DUNE-PRISM

Author: Kevin Kelly[1]

[1] *Fermilab*

Corresponding Author: kkelly12@fnal.gov

The upcoming DUNE Experiment will depend on precision measurement of neutrino fluxes and cross sections at its near detector in order to deliver on its stated neutrino physics goals, such as measurements of CP violation and the neutrino mass ordering, using its far detector. To this end, the DUNE-PRISM concept has been proposed – it consists of moving the near detector up to 36 m off-axis, allowing for measurements of different components of the neutrino flux. In addition, the DUNE near detector and PRISM concept allow for searches for new physics, such as light dark matter produced in the neutrino beam.

In this talk, I will discuss the capability of DUNE to search for light dark matter in the Near Detector facility. I will show that DUNE, particularly by leveraging the DUNE-PRISM concept, will allow for substantial improvement over existing searches for such dark matter, competitive with dedicated dark matter experiments in this regime.

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New physics in coherent neutrino scattering

Author: Xun-Jie XU[1]

[1] *Max-Planck-Institut fuer Kernphysik*

Corresponding Author: xunjie.xu@gmail.com

In this talk, I am going to review the recent progress of coherent neutrino-nucleus scattering experiments and summarize the constraints on various BSM physics, including NSI, SPVAT (Scalar Pseudoscalar, Vector, Axialvector, Tensor) interactions, sterile neutrinos, light mediators, neutrino magnetic moments, dark matter, etc.

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Effective Field Theory for NSI in Elastic Neutrino - Nucleus Scattering

Authors: Jure Zupan[1]; Michele Tammaro[None]; Wolfgang Altmannshofer[2]

[1] *University of Cincinnati*

[2] *UC Santa Cruz*

Corresponding Authors: waltmann@ucsc.edu, mike.tamma@gmail.com, jure.zupan@cern.ch

We formulate an Effective Field Theory (EFT) for Non Standard neutrino Interactions (NSI) in elastic scattering with light quarks, leptons, gluons and photons, including all possible operators of dimension 5, 6 and 7. We constrain the respective Wilson coefficient using the measurements by the COHERENT and CHARM collaborations. We also point out the constraining power of future elastic neutrino-nucleus scattering experiments. Finally, we explore the implications of the bounds for SMEFT operators above the electroweak breaking scale.

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Octant of theta23 and NSI degeneracy at DUNE

Authors: Antonio Palazzo[1]; Sabya Sachi Chatterjee[2]; Sanjib Kumar Agarwalla[3]

[1] *Bari University & INFN Bari*

[2] *Institute for Particle Physics Phenomenology, Durham University*

[3] *Institute of Physics, Bhubaneswar*

Corresponding Authors: antonio.palazzo@ba.infn.it, sabya.s.chatterjee@dur.ac.uk, sanjib@iopb.res.in

We expound in detail the degeneracy between the octant of θ23 and flavor-changing neutral-current non-standard interactions (NSI's) in neutrino propagation, considering DUNE as a case study. In the presence of such NSI parameters involving the e − μ (εeμ) and e − τ (εeτ) flavors, the νμ → νe and νμ → νe bar appearance probabilities in long-baseline experiments acquire an additional interference term, which depends on one new dynamical CP-phase φ{eμ/eτ}. This term sums up with the well-known interference term related to the standard CP-phase δ creating a source of confusion in the determination of the octant of θ23. We show that for values of the NSI coupling (taken one at-a-time) as small as few % (relative to the Fermi coupling constant GF), and for unfavorable combinations of the two CP-phases δ and φ{eμ/eτ}, the discovery potential of the octant of θ23 gets completely lost.

Session 7 / 6

New physics in rare neutrino scattering

Author: Matheus Hostert[1]

[1] *IPPP, Durham University*

Corresponding Author: matheus.hostert@durham.ac.uk

Rare and unique neutrino scattering processes can serve as an ideal tool in the search for new physics. In this context, I will present the sensitivity of the DUNE near detector to leptophilic Z' models, using neutrino-electron and neutrino trident scattering. I will conclude illustrating how similar signatures can also arise in more exotic models and motivating the need for a program to measure multi-lepton final states in current and future neutrino facilities.

Session 8 / 7

Liquid Argon Technology for Theorists

Author: Shirley Li[1]

[1] *SLAC*

Corresponding Author: shirleyli.phys@gmail.com

Available estimates for the energy resolution of DUNE vary by as much as a factor of four. To address this controversy, and to connect the resolution to the underlying physical processes, we build an independent simulation pipeline for neutrino events in liquid argon, combining the public tools GENIE and FLUKA. Using this pipeline, we first characterize the channels of non-hermeticity of DUNE, including subthreshold particles, charge recombination, and nuclear breakup. Particular attention is paid to the role of neutrons, which are responsible for a large fraction of missing energy in all channels. Next, we determine energy resolution, by quantifying event-to-event stochastic

fluctuations in missing energy. In the future, this framework can be used to assess the impact of cross section uncertainties on oscillation sensitivity.

Session 1 / 8

Overview of Neutrino Flavor Models

Author: Mu-Chun Chen[1]

[1] *UC Irvine*

Corresponding Author: muchunc@uci.edu

I will review current state of models of neutrino masses. I will discuss the models' implications for particle physics phenomenology and for cosmology.

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Beginnings of Quantum Monte Carlo Short-Time Approximation Implementations for electron and neutrino scattering from He4 and C12 in GENIE

Authors: Joshua Barrow[1]; Saori Pastore[2]; Steven Gardiner[3]

[1] *The University of Tennessee, FNAL*

[2] *WUSTL*

[3] *FNAL*

Corresponding Authors: gardiner@fnal.gov, jbarrow@fnal.gov

The study of inclusive neutrino (ν) cross sections and total fluxes for signs of (beyond) Standard Model interactions is critically dependent upon accurate theoretical modeling for consistent reconstruction of a ν's energy. Given the continuum of final state topologies available to such processes, the most popular form of this modeling within the experimental community generally occurs within event generators. One popular, longstanding, continually developing generator used today by Fermilab collaborations is GENIE; however, current simulations are usually based upon rather phenomenological, quasi-classical approximations, all fundamentally dependent upon underlying nuclear models which generally ignore crucial aspects of the nuclear response (such as nuclear many-body correlations). With a future path forward toward precision large scale experiments, a new lepton scattering GENIE module has begun development for ^{4}He and ^{12}C. This module will use nuclear response functions for electron scattering calculated with Quantum Monte Carlo computational methods that fully retain the complexity of the many-body correlations induced by the nuclear Hamiltonian and associated electroweak currents. Once completed, this module can be directly tested using world electron scattering data. Underlying physics, generator modeling assumptions, current implementation plans, and future comparisons will be discussed.

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Confronting Neutrino Mass Generation Mechanism with MiniBooNE Anomaly

Authors: SUDIP JANA[1]; Pedro Machado[2]; enrico bertuzzo[3]; renata zukanovich funchal[4]

[1] *OKLAHOMA STATE UNIVERSITY*

[2] *Fermilab*

[3] *Scuola Normale Superiore*

[4] *Universidade de São Paulo*

Corresponding Authors: sudip.jana@okstate.edu, enrico.bertuzzo@sns.it, pmachado@fnal.gov, zukanov@if.usp.br

We present a novel framework that provides an explanation to the long-standing excess of electron-like events in the MiniBooNE experiment at Fermilab. We suggest a new dark sector containing a dark neutrino and a dark gauge boson, both with masses between a few tens and a few hundreds of MeV. Dark neutrinos are produced via neutrino-nucleus scattering, followed by their decay to the dark gauge boson, which in turn gives rise to electronlike events. This mechanism provides an excellent fit to MiniBooNE energy spectra and angular distributions. We propose here to use this fact to connect the generation of neutrino masses to a light dark sector, charged under a new U(1)D dark gauge symmetry. We introduce the minimal number of dark fields to obtain an anomaly free theory with the spontaneous breaking of the dark symmetry and obtain automatically the inverse seesaw Lagrangian. In addition, the so-called μ-term of the inverse seesaw is dynamically generated and technically natural in this framework.

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Corresponding Author: sudip.jana@okstate.edu

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Light Mediators

In this talk, I will discuss light mediator models and various experimental constraints with particular emphasis on the recent results from the COHERENT experiment. I will show one particular example of such a model which contains sub-GeV dark matter.

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Corresponding Author: pmachado@fnal.gov

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Welcome Address by the Chair of Physics

Corresponding Author: alford@wustl.edu