UNIVERSITY OF MARYLAND

Department of Physics

Intensity Frontier Fellowship Closeout Report

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My Intensity Frontier Fellowship has focused on exploring two interesting theoretical possibilities that could have a major impact on the experimental neutrino physics program at Fermilab. In collaboration with Fermilab researchers Gordan Krnjaic and Pedro Machado, I am studying theories in which the parameters in the neutrino sector are not constant but vary in time, leading to unusual but striking signals in oscillation experiments. Separately, in collaboration with Fermilab scientists Patrick Fox and Roni Harnik, I am exploring the experimental signals of theories in which the neutrinos acquire masses through strong dynamics.

Krnjaic, Machado and I have constructed a realistic model in which the neutrino masses oscillate in time, leading to potentially observable effects in neutrino oscillation experiments. The variation in the neutrino masses is driven by a coupling to an ultralight scalar field that oscillates coherently in time, and that constitutes a subcomponent of the observed dark matter. The particle content of the model includes an exact mirror copy of the standard model fields and interactions. The mass of the ultralight scalar is stabilized against large radiative corrections by the same protection mechanism as is employed in Twin Higgs models. A late-time phase transition ensures that the oscillations of the scalar field remain large enough to produce observable effects on the neutrino mass spectrum. The mass of the ultralight scalar is a free parameter that can range over many orders of magnitude, allowing for a variety of signals in neutrino oscillation experiments. The DUNE and JUNO experiments, in particular, are expected to be especially sensitive to these effects.

Fox, Harnik and I are exploring models in which the neutrinos acquire Majorana masses through their couplings to right-handed neutrinos that emerge as composite states of a strongly coupled hidden sector. The smallness of neutrino masses is explained by the inverse seesaw mechanism, with the small parameters in the potential arising from dimensional transmutation in the strongly coupled theory. We focus on the scenario in which the compositeness scale lies at or below the weak scale. We find that this framework can lead to striking signals at colliders and fixed target experiments involving multiple displaced vertices. The DUNE Near Detector Hall is expected to be sensitive to these signals. If the compositeness scale lies below 100 MeV, the rate for neutrinoless double beta decay receives large corrections from quantum effects, and may be altered by an order of magnitude or more compared to the expected rate. The late decays of relic right-handed neutrinos can lead to spectral distortions in the cosmic microwave background that are large enough to be observed in future experiments.

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