Contribution ID: **119** Type: **Talk: in-person**

Flavor-Dependent Long-Range ν Interactions in DUNE and T2HK: Synergy Breeds Power

Thursday, 19 September 2024 17:15 (20 minutes)

Discovering new neutrino interactions would represent evidence of physics beyond the Standard Model. We focus on new flavor-dependent long-range neutrino interactions mediated by ultra-light mediators, with masses below 10^{-10}~eV, introduced by new lepton-number gauge symmetries $L_e - L_\mu$, $L_e - L_\tau$, and $L_\mu - L_\tau$. Because the interaction range is ultra-long, nearby and distant matter — primarily electrons and neutrons — in the Earth, Moon, Sun, Milky Way, and the local Universe, may source a large matter potential that modifies neutrino oscillation probabilities. The upcoming Deep Underground Neutrino Experiment (DUNE) and the Tokai-to-Hyper-Kamiokande (T2HK) long-baseline neutrino experiments will provide an opportunity to search for these interactions, thanks to their high event rates and well-characterized neutrino beams. We forecast their probing power. Our results reveal novel perspectives. Alone, DUNE and T2HK may strongly constrain long-range interactions, setting new limits on their coupling strength for mediators lighter than 10^{-18}~eV. However, if the new interactions are subdominant, then both DUNE and T2HK, together, will be needed to discover them, since their combination lifts parameter degeneracies that weaken their individual sensitivity. DUNE and T2HK, especially when combined, provide a valuable opportunity to explore physics beyond the Standard Model.

Working Group

WG 5: Neutrinos Beyond PMNS

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Session Classification: Parallel: WG 1x5

Track Classification: WG5: Neutrino Beyond PMNS