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Non-standard interactions and tau neutrino detection at DUNE

Thursday, October 2, 2025 8:30 AM (25 minutes)

Non-standard interactions (NSI) are a compelling beyond-the-Standard-Model (BSM) framework for explaining the tensions between the T2K experiment and the $operatorname{NO}\nu A$ experiment results. They can be formulated as general neutrino–or antineutrino–flavour-changing scattering processes with fermions in matter. In oscillation phenomenology, NSI enter as additional matter-potential terms in the Hamiltonian, leading to observable effects on oscillation probabilities for neutrinos and antineutrinos in matter.

We assess the impact of tau-neutrino data from the Deep Underground Neutrino Experiment (DUNE). DUNE is a next-generation long-baseline experiment. With its 1300 km baseline, it provides an exciting probe of matter effects in neutrino propagation through Earth. Its tau-optimized beam setup provides a unique method to constrain the NSI parameters. We find that the leading observable effect in the tau-neutrino channels arises from $\epsilon_{\mu\tau}$. Adding tau-neutrino appearance to the traditional muon-neutrino and electron-neutrino samples also yields a slightly stronger constraint on $\epsilon_{\mu\tau}$ than muon- and electron-neutrino data alone. In addition, using best fits of NSI parameters from T2K and $operatorname{NO}\nu A$, we compute DUNE's sensitivity to neutrino-oscillation parameters and to the mass hierarchy in the presence of NSI effects, and note that degeneracies can limit mass-ordering sensitivity. We consider the impact on sensitivity from the contributions of DUNE's regular beams, tau-optimized beams, and the combination of data from both beam types. We also show that tau-neutrino data improve tests of PMNS unitarity.

This study underscores the importance of tau-neutrino detection and appearance data in the DUNE experiment.

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