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Distinguishing Non-Standard Interaction and Lorentz Invariance Violation at the future long-baseline experiments

In the current era of precision measurements, one of the prime objectives of various neutrino oscillation experiments is to look for the signals of sub-leading effects in the three flavour neutrino oscillation framework. It is therefore, crucial to distinguish between the different new physics scenarios so that they their origin and implications can be well understood theoretically. As the two phenomena, Non-standard interactions in neutrino propagation (NSI) and Lorentz invariance violation (LIV) can modify the Hamiltonian of neutrino oscillation in a similar fashion, it is very difficult to distinguish these two effects. The only difference between them lies in the fact that NSI depends on the matter density, whereas LIV is independent of the earth matter effect. Therefore, for a fixed baseline experiment, where matter density is constant, the theories describing NSI and LIV are exactly equivalent. However, as the present and future bounds of the NSI and LIV parameters are not equivalent, one can distinguish these two scenarios in the long-baseline neutrino experiments depending on their statistics with respect to the present and future bounds of these parameters. In this work, we attempt to differentiate between LIV and NSI in the context of DUNE and P2SO, as these two future experiments are believed to be sensitive to the strongest matter effect and will have very large statistics. Taking LIV in the data and NSI in theory, our results show that, indeed it is possible to have good discrimination between LIV and NSI. The best separation between LIV and NSI at 3σ C.L. is achieved for the parameter $a_{\mu\mu}$ with P2SO. In this case, the value of LIV parameter for which separation is possible, lies within its future bound, if one considers the value of NSI parameter to be constrained by the present experiments. Between DUNE and P2SO, the latter has better sensitivity for such discrimination.

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