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Distinguishing CPT-Odd and CPT-Even Contributions of Lorentz Invariance Violation in Neutrino Oscillations

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Abstract: Lorentz Invariance Violation (LIV) refers to the breaking of Lorentz symmetry, which ensures that the laws of nature remain identical for all inertial observers. If such violations exist, they could appear as intrinsic effects even in vacuum, independent of external influences. Studying how LIV modifies standard neutrino oscillation probabilities therefore provides a powerful tool to test this possibility. Since LIV effects are expected to be sub-dominant compared to the standard oscillation dynamics, they are typically treated as small perturbations to the standard matter Hamiltonian [1]. Within the theoretical framework of the Standard Model Extension (SME) [2], these perturbations can be consistently parameterized and analyzed.

In this study, we incorporate the effective LIV Hamiltonian into the GLoBES simulation package [3] to perform numerical analyses of oscillation probabilities in the presence of LIV. Both CPT-odd (a) and CPT-even (c) components of LIV are examined independently, allowing us to distinguish their respective roles in shaping oscillation phenomenology. The energy dependence of the CPT-even LIV component makes it particularly interesting and we explore how its contribution differs from the LIV CPT-odd component. Using the Deep Underground Neutrino Experiment (DUNE) as a representative long-baseline setup, we investigate how LIV effects alter oscillation patterns, with special emphasis on the emergence of parameter degeneracies between LIV contributions and the standard oscillation parameters. Such degeneracies may obscure or mimic genuine oscillation effects, thereby influencing the interpretation of experimental results. We further assess their implications for precision measurements, focusing in particular on the sensitivity to leptonic CP violation.

References:

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