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Quantum Correlations in the Presence of Non-Standard Interactions in Neutrino Oscillations

We explore the imprints of non-standard interactions (NSI) on quantum correlations in the three-flavor neutrino oscillation framework using two complementary approaches. In the first study, we investigate tripartite entanglement measures, entanglement of formation, concurrence, and negativity, across reactor and accelerator experiments. We find that accelerator-based setups like DUNE exhibit enhanced sensitivity to NSI, with quantum entanglement measures revealing significant deviations from standard oscillation behavior, especially at moderate to high neutrino energies. In the second study, motivated by the recent tension between T2K and NOνA results, we analyze the violation of Leggett-Garg-type inequalities (LGtI) under complex NSI parameters $\epsilon_{e\mu}$ and $\epsilon_{e\tau}$. Our findings demonstrate that LGtI violations are significantly amplified in DUNE and NOνA, particularly for $\epsilon_{e\tau}$ in the normal ordering scenario, offering a possible signature of new CP-violating effects. Together, these results emphasize the power of quantum information theoretic tools, both spatial and temporal in probing new physics in the neutrino sector.

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