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Consistent QFT description of non-standard neutrino interactions

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Neutrino oscillations are precision probes of new physics beyond the Standard Model. Apart from neutrino masses and mixings, they are also sensitive to possible deviations of low-energy interactions between quarks and leptons from the Standard Model predictions. In this paper we develop a systematic description of such non-standard interactions (NSI) in oscillation experiments within the quantum field theory framework. We calculate the event rate and oscillation probability in the presence of general NSI, starting from the effective field theory (EFT) in which new physics modifies the flavor or Lorentz structure of charged-current interactions between leptons and quarks. We also provide the matching between the EFT Wilson coefficients and the widely used simplified quantum-mechanical approach, where new physics is encoded in a set of production and detection NSI parameters. Finally, we discuss the consistency conditions for the quantum-mechanical approach to correctly reproduce the quantum field theory result.