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Flavor-space analog to the Aharonov-Bohm effect for a constant scalar matter potential in neutrino flavor interferometry

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The Aharonov-Bohm effect is one of the most surprising wonders of the quantum world. Its interpretation is debated between a physical significance of the potential versus non-locality of quantum physics, ambiguity which cannot be resolved from all performed spatial interference experiments. We put forward the idea of replacing its study by flavor interferometry as observed in neutrino oscillations. The neutrino propagation through the crust of the Earth is affected by the constant scalar matter potential, with a phase shift between flavors and no force-field anywhere. Here we show how to signal and experimentally disentangle this phase shift by its symmetry properties. The energy dependence of the neutrino-antineutrino asymmetry in the golden transition $\nu_\mu \to \nu_e$ allows a clear separation of this matter component against the genuine asymmetry. Thus we find how to observe in a single experiment, like DUNE, the physical significance of the potential, the neutrino mass hierarchy and the genuine matter-antimatter asymmetry in the lepton sector.

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