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Probing neutrino nature and time reversal symmetry violation in elastic scattering of low energy neutrinos on polarized electrons in presence of nonstandard couplings

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Possibility of using elastic scattering of low energy electron neutrinos (ν_es) on polarized electron target (PET) for testing time reversal symmetry violation (TRSV) and neutrino nature (NN) in leptonic interactions is considered. We analyze the two theoretically possible scenarios of physics beyond the Standard Model (SM) in which flavor-conserving (FC) standard and non-standard interactions of left chiral (LC) and FC exotic couplings of right chiral (RC) ν_es are admitted.
The first option assumes that the incoming ν_e beam consists only of LC ν_es detected by $V-A$ and S,P,T interactions. It turns out that T-odd correlation built of the polarization of
the electron target, the incoming ν_e momentum and the outgoing electron momentum, and proportional to the interference between the S and T interactions in the cross section for the Dirac ν_es appears and results in a departure from the standard prediction for the azimuthal asymmetry of recoil electrons. The spectrum and polar distribution of recoil electrons are not sensitive to the T-odd correlation, but allow us to differentiate between Dirac and Majorana ν_es.
The second scenario is based on the assumption that the incoming ν_e beam is a superposition of LC states with RC ones. Consequently the transversal components of ν_e spin polarization (TCNSP) may appear and do not vanish in the limit of infinitesimally small ν_e mass.
LC ν_es interact mainly by the standard $V-A$ interaction, while RC ones are only detected by the exotic $V+A$ and S_R, P_R, T_R interactions.
The differential cross section for Dirac ν_es contains the interference terms between standard $V-A$ and exotic S_R, P_R, T_R couplings, while the differential cross section for the Majorana case does not include the interferences from V, T couplings. All the interferences are proportional to the various angular correlations (both T-even and T-odd) among the transversal
ν_e spin polarization, the polarization of the electron target, the incoming ν_e momentum and the outgoing electron momentum, and survive in the relativistic ν_e limit. In this way the azimuthal asymmetry, the electron spectrum and the polar angle distribution of the scattered electrons are sensitive to the TRSV and enable us to distinguish between Dirac and Majorana ν_es. The considerations are model-independent and carried out for the flavour (current) ν_es. To make such tests feasible, the intense (un)polarized artificial ν sources, PETs and the appropriate detector measuring both the polar and azimuthal angles of the outgoing electrons, and/or the recoil electrons energy with a high resolution have to be identified. This study is based on the published paper in the European Physical Journal C: W. Sobk\'ow, A. B\l{}aut, Eur. Phys. J. C {78}, 197 (2018), and the preprint arXiv:1812.09828.

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