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On the very nature of neutrinos: the inverse beta-decay as a test bench

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The lifetime of a particle is usually considered as one of its inherent features. On one hand, the lifetime of non-elementary quantum objects like pions or muons can be calculated from the knowledge of the interaction which rules their decay. On the other hand, other particles such as the electron are regarded as stable, in the sense that they do not decay at all (at least within Standard Model framework). In spite of this, decay properties are less fundamental than commonly thought, since they depend on the reference frame where they are evaluated. Along this line, the decay of accelerated protons was analyzed both in the laboratory frame (where the proton is accelerated) and in the comoving frame (where the proton is at rest and interacts with the Unruh thermal bath of electrons and neutrinos). The equality between the two rates was exhibited as a theoretical proof of the necessity of Unruh effect for the consistency of QFT. Recently, this formalism was refined, embedding the phenomenon of mixing for the emitted neutrinos. However, the question of whether to consider mass or flavor states for asymptotic neutrinos remained open. Here, we show that the only scenario compatible with: i) the general covariance of QFT, ii) the description of the phenomenologically observed neutrino oscillations, iii) CP-violation in neutrino oscillations is the one build upon flavor eigenstates. We further point out that Unruh radiation must be made up of oscillating neutrinos. For this purpose, we exploit previous results showing that Unruh bath for mixed fields loses its characteristic thermal spectrum. Possible experimental implications are investigated in connection with recent neutrino experiments such as Katrin and Ptolemy.

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