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Neutrino masses, oscillations, and 0nbb-decay

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A new Quantum Field Theory (QFT) formalism for neutrino oscillations in a vacuum is proposed. The neutrino emission and detection are identified with the charged-current vertices of a single second-order Feynman diagram for the underlying process, enclosing neutrino propagation between these two points. The L-dependent master formula for the charged lepton production rate is derived, which provides the QFT basis for analyzing neutrino oscillations. The observation of neutrino oscillations and hence non-zero neutrino masses provided a milestone in the search for physics beyond the Standard Model. An open question remains whether neutrinos are Dirac or Majorana particles. A smoking-gun signature of Majorana neutrinos is the observation of neutrinoless double-beta decay 0νββ-decay. The recent progress in the experimental and theoretical study of 0νββ-decay is shortly reviewed. A mechanism of generating Majorana neutrino mass due to the spontaneous breaking of chiral symmetry and forming a quark condensate is presented. The present-day results of the double-beta decay nuclear matrix elements calculation are discussed. An impact of the quenching of the axial-vector coupling constant on double-beta decay processes is addressed. The related experimental and theoretical studies of single ⊠-decay, 2νββ-decay, muon capture processes, and double-charge exchange nuclear reactions are also addressed.

Author: SIMKOVIC, Fedor

Presenter: SIMKOVIC, Fedor

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