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Time-Modulation of Two-Body Weak Decays with Massive Neutrinos

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Abstract:
In recent experiments at the GSI, Darmstadt, time-modulated orbital Electron Capture (EC) decays of H-like 140Pr58+, 142Pm60+, and 122I52+ ions with one electron in the K-shell, coasting in the ESR storage ring with velocity ß = 0.71, were observed. The EC-branches show exponential decay curves time-modulated with period T= 7.06(8) s and amplitude a = 0.18(3) for 140Pr decays, T = 7.10(22) s and a = 0.23(4) for 142Pm decays, and T = 6.04(6) s and a = 0.19(3) for 122I (preliminary) decays in the laboratory frame. The simultaneously measured ß+ branch of 142Pm shows no modulation with a < 0.03. We discuss here as origin of the modulation neutrino quantum beats produced by the superposition of massive neutrino mass-Eigen states emitted in the entangled two body weak decay. From the modulation frequency a value for the difference of the quadratic mass values $\Delta m^2 = m^2 2 - m^2 1 = 2.22(3) \times 10^{-4}$ eV² is deduced, which is 2.75 times larger than the value derived by the KamLAND antineutrino oscillation experiment. Vacuum polarisation effects of lepton-W-boson loops in the Coulomb-field of heavy nuclei are proposed to explain the difference of Δm^2 for neutrinos and antineutrinos. The origin of the small modulation amplitudes is discussed as the result of a partial restoration of the interference terms which are expected to cancel for the usual assumed unitarity of the neutrino flavour mixing matrix.

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