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The two-neutrino double beta decay and a determination of the effective axial-vector coupling constant

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We present an improved formalism of the two-neutrino double-beta decay rate. The dependence of energy denominators on lepton energies via the Taylor expansion is considered. The $2\nu\beta\beta$-decay rate depend on phase-space factors weighted by the ratios of $2\nu\beta\beta$-decay nuclear matrix elements
with different powers of the energy denominator. For nuclei of experimental interest all phase-space factors are calculated by using exact Dirac wave functions with finite nuclear size and electron screening. For isotopes with measured $2\nu\beta\beta$-decay half-life the involved nuclear matrix elements are determined within the quasi-particle random-phase approximation with partial isospin restoration. The importance of correction terms to the $2\nu\beta\beta$-decay rate due to Taylor expansion is established and the modification of shape of single and summed electron energy distributions is discussed. It is found that the improved calculation of the $2\nu\beta\beta$-decay predicts slightly suppressed $2\nu\beta\beta$-decay background to the neutrino-less double-beta decay signal. Further, an approach to determine the value of the effective weak-coupling constant in nuclear medium $g_{\rm A}^{\rm eff}$ is proposed.

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