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Improved description of double beta decay

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We present the Taylor expansion formalism for describing the two-neutrino double-beta ($2\nu\beta\beta$) decay. In predicting the $2\nu\beta\beta$ decay spectra, we include the radiative and atomic exchange correction. We also investigate the impact of the electron phase shift on the angular correlation between the emitted electrons. Additionally, we examine the contribution of all s-wave electrons available for capture in the two-neutrino double electron capture (2νECEC) processes, going beyond the K and L_1 orbitals considered in prior studies. Finally, we propose a semi-empirical formula (SEF) for calculating the nuclear matrix elements (NMEs) for both the $2\nu\beta\beta$ decay and 2νECEC process. Compared with the previous phenomenological and nuclear models, the SEF yields the best agreement with the experimental NMEs.

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