Advances in the calculation of double beta decay

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Abstract

The fundamental nature and the absolute mass scale of the neutrino is a subject of great interest at the present. In order to study these issues the nuclear $\beta\beta$-decay is utilized. For an extraction of the neutrino mass and for estimates of the half-life, besides the involved nuclear matrix elements, one also needs the phase-space factors $G_{0\nu}$ and $G_{2\nu}$. A general formulation was a given long time ago; however, in previous calculations an approximate expression for the electron wave function at the nucleus is used. We have done an independent calculation with exact Dirac electron wave functions including screening by the electron cloud. The influence to the phase-space factors is seen especially for the heavier $\beta\beta$-decaying nuclei.

Both modes of $\beta\beta$-decay also depend on the coupling constant g_A as g_A^4. It is well known from single β-decay that g_A is renormalized in nuclei. The amount of renormalization depends on the size of the model space, and hence on the nuclear model used to calculate the decay probability. Since $2\nu\beta\beta$ decay has now been measured in several nuclei, it provides a way to estimate $g_{A,eff}$ and thus a better estimate of the half-life for $0\nu\beta\beta$ decay.

All the above mentioned results are combined with recently calculated IBM-2 nuclear matrix elements. The advantage of this method is that it can be used in any nucleus and thus all nuclei of interest can be calculated within the same model leading to a more reliable estimates of the half-life in both modes and prediction for neutrino mass using recent experimental achievements, such as, measurement of half-life for $2\nu\beta^-\beta^-$-decay in ^{136}Xe by the EXO collaboration, precise determination of the $\beta^-\beta^-$-decay Q-value in ^{110}Pd by the CERN-ISOLDE collaboration and a new half-life limit for $0\nu\beta^-\beta^-$-decay in ^{136}Xe from KamLAND-zen experiment, to give most up-to-date information.