Effect of induced currents in the calculation of nuclear transition matrix elements of neutrinoless double beta decay within PHFB model

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Introduction

Theoretical as well as experimental study of neutrinoless double beta $(\beta\beta)_{0\nu}$ decay in which the lepton number is violated by two units, is a convenient tool for ascertaining the mass and nature of neutrinos. The mechanism of $(\beta\beta)_{0\nu}$ decay requires the massive Majorana neutrino. Hence, it has the potential to probe new physics beyond the standard model of electroweak unification. Besides the mass and nature of neutrinos, limits on various other gauge theoretical parameters can also be extracted from the observed experimental limits on half-lives $T_{1/2}^{(0\nu)}$ of $(\beta\beta)_{0\nu}$ decay by calculating the appropriate nuclear transition matrix elements (NTMEs).

In order to obtain reliable limits on these gauge parameters, the calculated model dependent NTMEs should be as accurate as possible. The calculation of accurate NTMEs is quite a challenging task as different NTMEs are obtained by employing distinct nuclear models, for a given transition. Further, for a given model, NTMEs also depend on the model space and effective two-body interaction. The other factors responsible for the uncertainties are the inclusion of pseudoscalar and weak magnetism terms in the Fermi, Gamow-Teller and tensorial NTMEs, finite size as well as short range correlations (SRC), and the use of two effective values of the axial-vector coupling constant g_A.

It has been reported by Simkovic et al. [1] and Vergados [2] that the contributions of the induced currents, i.e. pseudoscalar and weak magnetism terms of the recoil current in mass mechanism can change NTMEs up to 30%, which has been recently confirmed in the shell model calculation of Strassbourg-Madrid group as well as in IBM. The main objective of the present work is to study the effects of pseudoscalar and weak magnetism terms on the Fermi, Gamow-Teller and tensorial NTMEs for the $(\beta\beta)_{0\nu}$ decay within PHFB model. The detailed results will be presented in the symposium.

Theoretical framework

The details about the model space, single particle energies, *PQQ* type of effective two-body interaction and the procedure to fix its parameters have been given in Refs. [3-8]. The Hamiltonian of the effective two-body interaction used in the present work is given as

$$H = H_{s.p.} + V(P) + V(QQ) + V(HH) \qquad (1)$$

where $H_{s.p.}$, $V(P)$, $V(QQ)$ and $V(HH)$ denote the single particle Hamiltonian, pairing, quadrupole-quadrupole and hexadecapole-hexadecapole parts of the effective two-body interaction. We use four different parametrizations of the interaction Hamiltonian, namely *PQQ*1, *PQQ*2, *PQQHH*1 and *PQQHH*2 [8]. Further, we use the Jastrow type of short range correlations with Miller-Spencer, Argonne V18 and CD-Bonn NN potentials [8,9]. The theoretical formalism to calculate the half-life of the $(\beta\beta)_{0\nu}$ decay as well as NTMEs including induced currents has been given by Simkovic et al. [1] and Vergados [2].

Results and discussions

Some preliminary results of the calculated NTMEs $M_N^{(0\nu)}$, including induced currents for heavy Majorana neutrino exchange of $(\beta\beta)_{0\nu}$ decay, are presented in Table 1.

Table 1: Calculated NTMEs $M_N^{(0\nu)}$ of ^{100}Mo in the PHFB model. The $M_N^{(0\nu)}$ in second and third column are given without and with the inclusion of induced currents (IC).

	$\lvert M_N^{(0\nu)}\rvert$ (without IC)	$\lvert M_N^{(0\nu)}\rvert$ (with IC)
P	608.15	541.87
P+SRC1	0.0	13.6490
P+SRC2	3.89	67.06
P+SRC3	177.34	156.30
F	385.51	372.83
F+SRC1	199.08	129.00
F+SRC2	301.69	223.34
F+SRC3	359.98	304.48

The results in Table 1 are calculated within PHFB model using *PQQ*1 parametrization. The P, P+SRC, F and F+SRC denote point nucleons, point nucleons plus Jastrow type of SRC, finite size of nucleons with dipole form factor and finite size plus SRC, respectively. Further, the SRC1, SRC2 and SRC3represent short range correlations with Miller-Spencer, Argonne V18 and CD-Bonn NN potentials, respectively. It can be observed from Table 1 that inclusion of effects due to induced currents reduces the NTMEs substantially. Results will be more interesting and conclusive when the calculation will be performed over all the ββ emitters in the mass range A=90-150 using four parametrization within PHFB model. Work is in progress and the detailed results will be presented in the symposium.

Conclusions

To summarize, we study the effect of induced currents on the calculation of NTMEs of $(\beta\beta)_{0\nu}$ decay using the Jastrow type of SRC with Miller-Spencer, Argonne V18 and CD-Bonn NN potentials employing four sets of wave functions generated through the projected Hartree-Fock Bogoliubov model.

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