Two-neutrino $0^+ \to 0^+$ double beta decay of ^{48}Ca in the DFT-NCCI framework

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Two-neutrino double beta decay ($2\nu\beta\beta$) is a second-order weak-interaction process. Consequently, it is among the rarest radioactive processes observed in nature. The theoretical relationship between the measured half-life $T_{1/2}$ and the quantum mechanical probability of the decay is given by:

$$T_{1/2}^{-1} = G_{2\nu\beta\beta} \cdot |\mathcal{M}_{2\nu\beta\beta}|^2, \tag{1}$$

where $G_{2\nu\beta\beta}$ denotes the kinematic leptonic phase-space factor, and $\mathcal{M}_{2\nu\beta\beta}$ is the nuclear matrix element containing cumulative nuclear-structure-dependent information about transition rates between nuclear quantum states active in the process.

The $2\nu\beta\beta$ decay, although well known, has recently attracted significant attention due to substantial investments in the search for the yet unobserved neutrinoless double beta decay ($0\nu\beta\beta$), a process considered a potential gateway to *new physics* beyond the Standard Model. Current efforts focus on high-precision half-life measurements and, on the theoretical side, on high-precision calculations of the nuclear matrix elements using various theoretical models.

In this talk, we present the results of our seminal calculation of the nuclear matrix element for the $2\nu\beta\beta$ decay ^{48}Ca $\to$ ^{48}Ti, performed using a post-Hartree-Fock (HF) Density Functional Theory-based No-Core Configuration-Interaction (DFT-NCCI) framework developed by our group [1]. The preliminary value we have obtained for the nuclear matrix element describing this process, $|\mathcal{M}_{2\nu\beta\beta}| = 0.063(6)\,\mathrm{MeV}^{-1}$, is in excellent agreement with the results of the shell-model study by Horoi *et al./* [2], which yielded 0.054 (0.064) MeV^{-1} for the GXPF1A (GXPF1) interactions, respectively. It is also in reasonable agreement with the most recent experimental estimate from the review by Barabash [3], which is $0.074(6)\,\mathrm{MeV}^{-1}$, assuming a quenching factor $qg_{\mathrm{A}} \approx 1$. The consistency of our prediction with the shell-model results strengthens our confidence in the nuclear modeling of this second-order, extremely rare process, which is of paramount importance for the further modeling of the $0\nu\beta\beta$ decay.

[1] W. Satuła *et al.*, Phys. Rev. C **94**, 024306 (2016)
[2] M. Horoi *et al.*, Phys. Rev. C **75**, 034303 (2007)
[3] A. Barabash, Universe **6**, 159 (2020)