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Shell-model calculations of the neutrinoless double-beta decay matrix elements

Contenu

Between the late 1990s and the early 2000s, the observation that solar and atmospheric neutrinos oscillate has indicated that these elusive particles have nonzero mass, and has supported investigations to search for physics beyond the standard model. This discovery has revived interest in the study of neutrinoless double-β decay (0νββ), a rare second-order electroweak process that, if occurring, would provide fundamental knowledge about the nature of the neutrino.
The standard mechanism that is considered in a 0νββ-decay is the exchange of a light Majorana neutrino, and in such a framework the half-life depends on the phase-space factor, that can be calculated with high accuracy, on the nuclear matrix element, that strongly depends on the nuclear model adopted, on the axial coupling constant and on the effective neutrino mass.
We approach the calculation of the nuclear matrix element of the 0νββ-decay process, considering the light-neutrino-exchange channel, by way of the realistic shell model. To this end, we start from a realistic nucleon-nucleon potential and then derive the effective shell-model Hamiltonian and 0νββ decay operator within the many-body perturbation theory. We focus on investigating the perturbative properties of the effective shell-model operator of such a decay process, aiming to establish the degree of reliability of our predictions. Our results for the different candidates, ^{48}Ca, ^{76}Ge, ^{82}Se, ^{130}Te ^{136}Xe [1] and, more recently, for ^{100}Mo [2], provide evidence that the effect of the renormalization of the 0νββ-decay operator on the values of the nuclear matrix elements is less relevant than what we obtain for the effective single-body Gamow-Teller transitions operating also in the two-neutrino double-β decay.

References
[1] L. Coraggio et al. Phys. Rev. C **101**, 044315 (2020)
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Auteurs principaux: Dr DE GREGORIO, Giovanni (Università della Campania "Luigi Vanvitelli" & INFN--Napoli); Dr GARGANO, Angela (INFN, Napoli); Prof. CORAGGIO, Luigi (Università della Campania "Luigi Vanvitelli" &INFN, Napoli); Prof. ITACO, Nunzio (Università della Campania "Luigi Vanvitelli" &INFN, Napoli)

Orateur: Dr DE GREGORIO, Giovanni (Università della Campania "Luigi Vanvitelli" & INFN-Napoli)

Déposé par **Dr DE GREGORIO, Giovanni** le **mardi 19 avril 2022**