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Novel microscopic approaches for Spin-Isospin excitations

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The spin-isospin excitations including beta-decay may have strong impacts on the study of strong interactions in nuclear medium, and also the astrophysical phenomena such as the r-process nucleosynthesis together with the photonuclear cross sections, and the large-scale nucleosynthesis network calculations to create elements in the universe. In addition, the Gamow-Teller (GT) and spin-dipole (SD) resonances are
associated with double-beta decay processes, especially, for the zero-neutrino double-beta decay, which provides the information of neutrino-mass puzzle, and consequently the evidence beyond the standard model of elementary particles.

We explore extensively new and old, but still unsolved, nuclear structure problems induced by the spin and isospin degree of freedom
by using microscopic models which accommodate realistic isoscalar and isovector pairing interactions, and also tensor correlations [1].
For the attempt of universal theoretical framework for both nuclear and astrophysical phenomena, we adopt a self-consistent Hartree-Fock (HF)+random phase approximation (RPA) models embedded the tensor interactions [2], and a state-of-the-art beyond mean field model, Subtracted Second RPA (SSRPA) [3] including the couplings to two-particle two-hole (2p-2h) states.
Especially we study magnetic dipole (M1) [2,3], charge-exchange Gamow-Teller (GT) [1,3] and spin-dipole excitations. We mention also pigmy and giant resonances induced by the tensor interaction. Our results give a new insight on the quenching of GT sum rule strengths without introducing any free parameters in the self-consistent microscopic calculations. The SSRPA model is further applied to the
decay half-lives of four semi-magic and magic nuclei,
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and
[3]. We show the inclusion of the 2p-2h configurations in SSRPA model shifts low-lying Gamow-Teller (GT) states downwards, and leads to an increase of the
decay phase space, and consequently reproduce the
decay half-lives dramatically close to the experimental observations. The effect of tensor interaction on the decay half-life in SSRPA model is also pointed out to change largely the half-lives by about one to two orders of magnitude with respect to the ones obtained without tensor force.

We derived recently the charge symmetry breaking (CSB) EDF based on the QCD sum rule ap-proach [4]. We will discuss also the effect of QCD-based CSB on the double beta decay probabilities and eventually the neutrino mass puzzle.

References
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