Gamow-Teller transitions in magic nuclei calculated based on the charge-exchange subtracted second random phase approximation[†]

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We studied the Gamow-Teller (GT) transitions in four magic nuclei, *i.e.*, ^{48}Ca, ^{90}Zr, ^{132}Sn, and ^{208}Pb based on a self-consistent Hartree-Fock (HF) + subtracted second random phase approximation (SSRPA) model with different Skyrme energy density functionals (EDFs). The SSRPA model describes systematically and quantitatively the GT strength distribution in the four nuclei better than the RPA model.

The results of SAMi-T[1)] with and without tensor terms are shown in Fig. 1. Specifically, SGII[2)] and SAMi-T EDFs well reproduce the strength distributions of the main GT peaks in terms of the excitation energy and peak height in comparison with the experimental data, except for ^{90}Zr, in which the calculated peak height is approximately two times larger than the experimental result. We examined the effect of tensor terms of the SAMi-T EDF and found that the terms shift the main peaks downward by approximately 1 MeV in ^{48}Ca, ^{132}Sn, and ^{208}Pb; however, they hardly affect ^{90}Zr. The quenching factor has increased slightly; however these values with the tensor interactions are still about a half of the experimental quenching factors. We explored the possibility whether the tensor force with different strengths further enhances the quenching factor of the GT strength. To this end, we adopt the T21, T44, and T55 EDFs from the TIJ family[3)] with different values of of the tensor terms. We realized that none of these three parameter sets well described the strength distributions. However, the T55 EDF produces large quenching factors: 30% for ^{48}Ca, 25% for ^{90}Zr, 27% for ^{132}Sn, and 19% for ^{208}Pb. In ^{208}Pb, the quenching factors are smaller, which is related to the insufficient cutoff energy of $2p$-$2h$ configurations.

Further we studied the role of tensor interactions in quenching with the parameter sets, *i.e.*, SGII + Te1, SGII + Te2, and SGII + Te3 keeping the central part unchanged. With these parameter sets, we found that the tensor interactions significantly affect the strength distributions of GT peaks, *i.e.*, strong effect on the spreading of the strength distribution and shift of the excitation energy. Among the parameters, SGII + Te1 best reproduces the GT strength distributions in the four nuclei. While the SGII + Te1 and SGII + Te3 EDFs, in which the strengths of the triplet-odd tensor term are significantly different even in the sign, produce large quenching factors similar to those of T55. In addition, as SGII is optimized excluding J^2 terms, we performed the calculations in which the J^2 terms are excluded in HF and SSRPA for the SGII EDF. The calculations indicate that the exclusion of J^2 terms originated from the momentum dependent interactions generates larger quenching factors, close to experiments. However, the systematical description of the strength distributions in the four nuclei has not improved much compared to those with the J^2 terms. It is still a challenge to describe realistic strength distributions and large quenching factors with Skyrme EDFs.

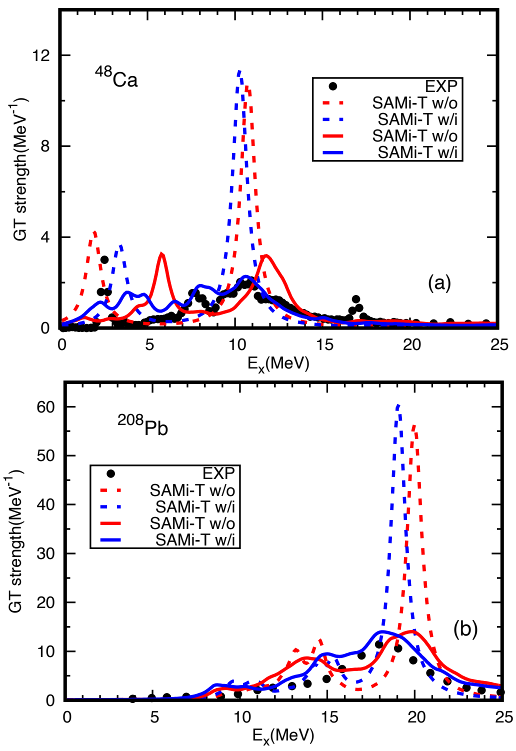

Fig. 1. GT_- strength distributions of ^{48}Ca [panel (a)], and ^{208}Pb [panel (b)] calculated with SAMi-T by RPA (dash lines) and SSRPA (solid lines) with or without tensor terms. The red lines represent SAMi-T without tensor terms labeled w/o, and the blue lines represent SAMi-T with tensor terms labeled w/i. Experimental data are taken from Ref. 4) for ^{48}Ca and Ref. 5) for ^{208}Pb.

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