Gamow-Teller strength distributions of ^{18}O and well-deformed nuclei ^{24}Mg and ^{26}Mg by deformed QRPA†

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The Gamow-Teller (GT) excitation is a key transition for studying the weak interaction of nuclei through charge-exchange (or charged-current) reactions, beta decays, and electron or muon capture reactions. Recent progress in the study of supernova neutrinos has revealed that the GT transition is a crucial transition in neutrino-induced reactions. Microscopic studies of the GT transitions of finite nuclei may have a strong impact on these astronomical calculations, yielding constraints for key ingredients.

The main aims of the present work are to study the interplay between the deformation and GT strength distributions, and the role of particle-particle (*p*-*p*) and particle-hole (*p*-*h*) type correlations for the low- and the high-lying GT peaks. To this end, we perform deformed quasi-particle random phase approximation (DQRPA) calculations with a realistic residual interaction, determined from the Brückner *G*-matrix with the CD Bonn potential. We use the Skyrme-type mean-field potential for calculations of deformed single-particle states. For the application of the present DQRPA model, we select the GT transitions of two Mg isotopes, ^{24}Mg and ^{26}Mg, because they are known as well-deformed nuclei. In addition, there are precise GT experimental data using ^{3}He and triton beams for these nuclei. We also studied a spherical nucleus ^{18}O as a complementary example to the strongly deformed nuclei.

Figures 1(b) and (c) show numerical results for the B(GT$^-$) strength distribution from ^{26}Mg. The DHFB results suggest a large deformation $\beta_2 = 0.45$, and the experimental data of GT strengths are well described by the DQRPA calculations with $\beta_2 = 0.45$ both the low-lying and high-lying GT peaks. It should be noticed that a large deformation $\beta_2 = 0.45$ is consistent with the experimental data of the E2 transition strength. The result with no deformation $\beta_2 = 0.0$ is also presented in the panel (c). As seen in Fig. 1(c), the latter result does not reproduce the low-lying GT peak, but shows a large GT strength of approximately 7 MeV, in which the experimental data do not show any significant strength.

The cumulative sums of GT$^\pm$ strengths of ^{24}Mg and ^{26}Mg were studied in the low-energy region where the experimental data are available. Our SHFB + QRPA results give a good account of the sum rule values with a quenching factor $q = 0.684$ for the GT operator. We found similarities in the GT strength distributions of $N = Z$ nuclei with those of $N = Z + 2$ nuclei.[2)] This implies that the low-lying GT states in $N = Z$ ($N = Z + 2$) nuclei are enhanced mainly by the *p*-*h* (*p*-*p*) interaction, and relatively small GT strengths appear in the higher energy region in the case of the nuclei studied in this article. We argued that the strong deformation is responsible to cause this phenomenon so that the relevant residual interactions are a combination of *p*-*p* and *p*-*h* interactions, as shown in ^{24}Mg and ^{26}Mg, due to the smearing of the Fermi surface by pairing correlations. By contruct, this phenomenon does not appear in the case of the ^{18}O nucleus since it is spherical.

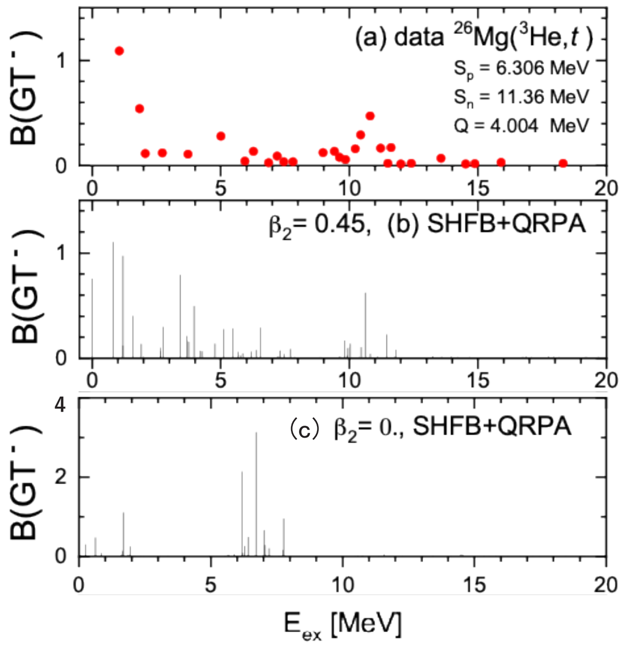

Fig. 1. B(GT$^-$) transition strength distribution from ^{26}Mg by various deformation (b) for $\beta_2 = 0.44$ and (c) for $\beta_2 = 0.0$. Experimental data in panel (a) are taken from.[1)]

References
1) R. G. T. Zegers *et al.*, Phys. Rev. C **74**, 024309 (2006); S. Noh *et al.*, Jpn. J. Appl. Phys. **40**, L1299 (2001).
2) E. Ha, M. -K. Cheoun, H. Sagawa, Prog. Theor. Exp. Phys. **2024**, 063D02 (2024).

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