High-Lying Excited States in Gamow Teller Strength and Their Roles on Neutrino Reactions

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The Gamow Teller (GT) transition strengths deduced from charge exchange reactions (CEXRs) are very helpful for understanding the nuclear reaction induced by the solar neutrino. For further study of supernovae (SNe) neutrinos in the cosmos, one needs to study high-lying GT states around a few tens of MeV region as well as other multipole transitions because of the high energy tail in the neutrino spectra emitted from the neutrino sphere. In this report, we address the importance of the high-lying GT excited states, which data now become available from various CEXR experiments. For example, the GT(±) strength up to 70 MeV are successfully extracted by ^{90}Zr(n, p) and ^{90}Zr(p, n) reactions [1].

Our discussions are extended to investigate roles of the high-lying states beyond a few low-lying states known in the old experiment on the reaction induced by SNe neutrinos particularly on ^{40}Ar target. The nucleus was originally exploited to identify the solar neutrino emitted in the pp-chain, and now lots of applications for more energetic neutrino detection are under progress. Expected large difference between the cross sections of ν_e and $\bar{\nu}_e$ reactions on ^{40}Ar, which difference were anticipated because of the large Q value in the $\bar{\nu}_e$ reaction, is significantly diminished compared to previous results. Our calculations are carried out by the Quasiparticle Random Phase Approximation (QRPA), which takes the neutron-proton pairing into account to the standard proton-neutron QRPA (pnQRPA) where only proton-proton and neutron-neutron pairing correlations are considered.

First, we compare our theoretical results to recent experimental GT(∓) strength distribution data [1] which were deduced by the multipole decomposition (MD) technique from ^{90}Zr(p, n) at the bombarding energy 295 MeV and ^{90}Zr(n, p) at 293 MeV reactions. In such a high energy region, the $\Delta L = 0$ contribution from the isovector spin monopole (IVSM) can be included around 35 MeV region in the GT strength. By extracting $\Delta L = 0$ IVSM contribution with the MD technique, they succeed to obtain the ISR value about 90 %.

In Fig. 1, we show the GT strength distributions and their running sums by the the QRPA. The GT strengths are clearly redistributed by the np pairing in the QRPA. If we compare to the experimental data [1], two peak positions around 3(9) and 10(16) MeV regions w.r.t ^{90}Nb (^{90}Zr) are well reproduced in the QRPA. This result is also consistent with previous results by the Dressed RPA. Also the quenching factor data related to total running sums, $Q = (S_- - S_+)/(3(N - Z)) = 0.90 \pm 0.05$ or 0.88 ± 0.06 [1], are almost reproduced by our results 0.96, although strength shapes are a bit different from the experimental data. Since only the GT states are considered in this work, our results beyond 20 MeV are not presented in Fig. 1. Detailed discussion are done at Ref. [2].

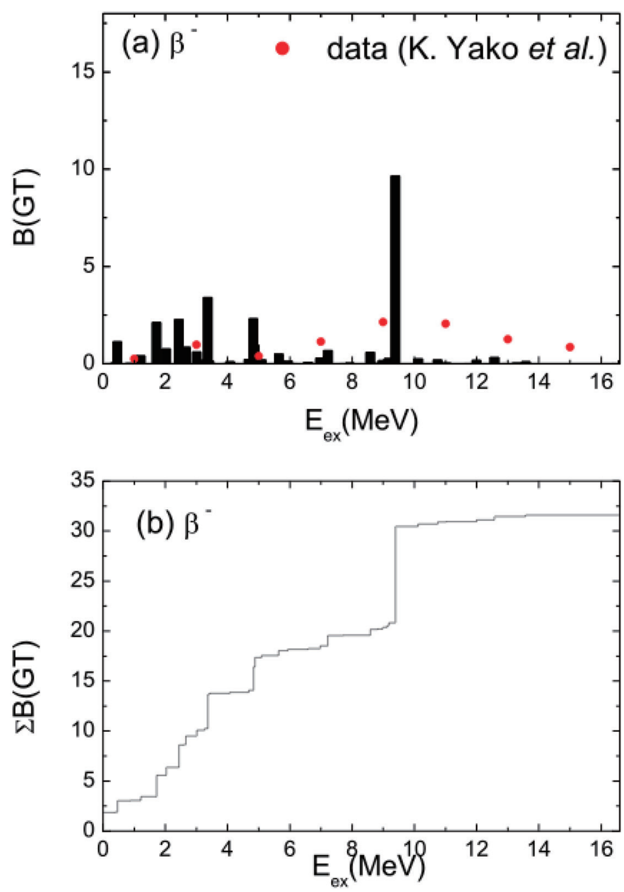

Figure 1: GT(−) strength distributions and their running sums for ^{90}Zr by the QRPA. Experimental data [1] are denoted as red points by subtracting the experimental Q value between ^{90}Zr and ^{90}Nb.

References

[1] Cheoun, M.-K., Ha, E., Kajino, T.: 2012, *Eur. Phys. J.*, **48**, 137.
[2] Yako, K., et. al.: 2005, *Phys. Lett. B*, **615**, 193.