Detailed Distributions of Gamow-Teller Strengths in $T_z = 0$ nucleus ^{46}V

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Gamow-Teller transitions play important roles in the core collapse of presupernova. At the end of the evolution of massive star, if the iron core in the center exceeds the so-called Chandraseker mass limit, the star starts to collapse. This is the beginning of the type II supernova [1]. In the early stage of collapse, the electron capture and β decay work together to accelerate the collapse. The electron degeneracy pressure cannot support the core any longer because of the lepton number reduction in the core, and neutrino release energy from the core. The electron capture and β decay are dominated by the Gamow-Teller (GT) transitions. The information on reduced GT transition strengths, $B(\mathrm{GT})$ values, for fp-shell nuclei is important to understand the mechanism of the core collapse.

The most direct measurement of $B(\mathrm{GT})$ values comes from β-decay studies. The information, however, is limited only for low-lying region due to Q-value limitation. To map $B(\mathrm{GT})$ distribution above higher excitation region, charge exchange (CE) reactions, like a (p,n) reaction, at an intermediate energy and at 0° were used [2, 3], because there is a proportionality between cross sections and $B(\mathrm{GT})$ values. This proportionality is due to the fact that at $q = 0$, $\sigma\tau$ part of the effective nucleon-nuclear interaction is dominant, and simple reaction mechanism of one step process is expected [4]. With a typical resolution of 300 keV in a (p,n) reaction, the outline of GT distribution was obtained for fp-shell nuclei. However, as the result of the improvement of the resolution by using $(^3\mathrm{He},t)$ reaction, it was found that GT states were fragmented over many states.

We perform a $^{46}\mathrm{Ti}(^3\mathrm{He},t)^{46}\mathrm{V}$ reaction at 140 MeV/u and at 0° at RCNP. The target nucleus, ^{46}Ti has $T_z = +1$ and GT transitions to $T_z = 0$ odd-odd nucleus ^{46}V were examined. The spectrum is shown in Fig. 1. The energy resolution ΔE was 27 keV by applying the *dispersion matching techniques* [5]. Owing to the high energy-resolution, well separated states were observed in the excited region up to 6 MeV. The scattering angle was reconstructed well by applying *angular dispersion matching techniques* and *over focus mode* [6]. We could extract the events for scattering angles $\Theta \leq 0.5°$. In the metallic foil of ^{46}Ti, 10.6 % of ^{48}Ti is contained. In order to identify the states originated from ^{48}Ti in the ^{46}Ti spectrum, we also took the ^{48}Ti spectrum under the same condition as ^{46}Ti. From the comparison of two spectra, several small peaks observed in the spectrum were found to be originated from^{48}Ti. In the ^{46}Ti spectrum at 0°, states with $\Delta L \geq 1$ characters can be weakly excited. To distinguish GT transitions with $\Delta L = 0$ character from the states with other higher multipoles, we compared 0.0°- 0.5° spectrum with 0.5°-1.0°, 1.0°-1.5° and 1.5°-2.0° spectra.

In order to calculate $B(\mathrm{GT})$ values from the experimental peak intensities by applying the proportionality between cross sections and $B(\mathrm{GT})$ values, the standard $B(\mathrm{GT})$ value is needed. One of the ways is to obtain it from analogous β-decay measurement under the assumption of isospin symmetry structures in the same mass system. Unfortunately, however, the analogues $B(\mathrm{GT})$ values are not accurately known from $^{46}\mathrm{Cr}$ β decay measurement. Therefore, we try to derive $B(\mathrm{GT})$ values with the other method. For GT and Fermi transitions, the proportionality between cross sections and reduced transition strengths of $B(\mathrm{GT})$ and $B(\mathrm{F})$, respectively, are expected for a nucleus with a certain mass A. The proportinal factors are called the unit cross sections, $\hat{\sigma}(\mathrm{GT})$ and $\hat{\sigma}(\mathrm{F})$, respectively. The ratio of GT and Fermi unit cross sections is defined by [3],

$$R^2 = \frac{\hat{\sigma}(\mathrm{GT})}{\hat{\sigma}(\mathrm{F})} = \frac{\sigma(\mathrm{GT})/B(\mathrm{GT})}{\sigma(\mathrm{F})/B(\mathrm{F})} \tag{1}$$

We can assumed that the Fermi transition is concentrated to the *isobaric analog state* (IAS), and has $B(\mathrm{F}) = N - Z$. We also assume that the R^2 value is a smooth function of mass A. The R^2 mass dependence of $(^3\mathrm{He}, t)$ reaction should be measured systematically. For $A = 7$, 18, 26 and 58 systems, R^2 values could be calculated from the $^7\mathrm{Li}$, $^{18}\mathrm{O}$, $^{26}\mathrm{Mg}$ and $^{58}\mathrm{Ni}$ $(^3\mathrm{He}, t)$ experiments. From these $(^3\mathrm{He}, t)$ experiments, the ratio of GT and Fermi cross sections, $\sigma(\mathrm{GT})$ and $\sigma(\mathrm{F})$, are obtained from the experimental peak intensities. The $B(\mathrm{GT})$ values could be estimated from the analogous β-decay measurements of $^7\mathrm{Be}$, $^{18}\mathrm{Ne}$, $^{26}\mathrm{Si}$ and $^{58}\mathrm{Cu}$. From $\sigma(\mathrm{GT})$, $\sigma(\mathrm{F})$, $B(\mathrm{GT})$ and $B(\mathrm{F})$, the R^2 values were obtained for these mass systems. It was found that R^2 value increases as a mass number increases in the region of $A = 7 \sim 58$, With the interpolation, the R^2 value was 9.1(6) for A=46. The $B(\mathrm{GT})$ value of each GT transitions in $^{46}\mathrm{V}$ was extracted using $B(\mathrm{F}) = 1$, $R^2 = 9.1(6)$ and $\frac{\sigma(\mathrm{GT})}{\sigma(\mathrm{F})}$ which is the ratio of GT and Fermi peak intensities observed in the spectrum. The preliminary $B(\mathrm{GT})$ distribution is shown in Fig. 2.

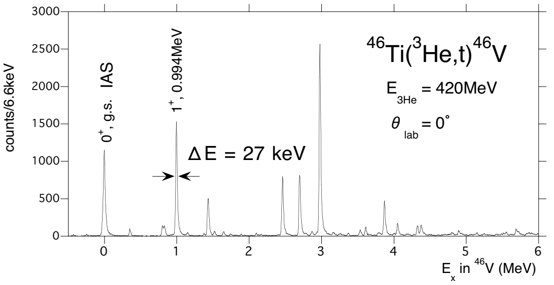

Figure 1: The low-excitation spectrum of $^{46}\mathrm{Ti}(^3\mathrm{He}, t)^{46}\mathrm{V}$. The energy resolution ΔE was 27 keV for the $E_x = 0.994$ MeV, 1^+ state.

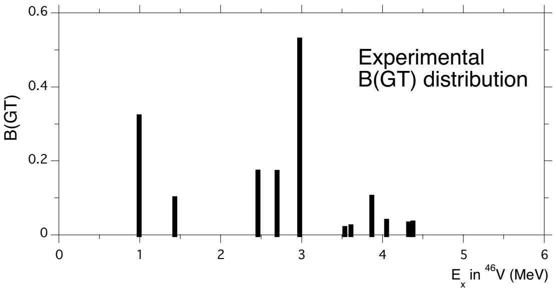

Figure 2: The preliminary $B(\mathrm{GT})$ distribution in $^{46}\mathrm{V}$. The main part of the strength concentrates below about E_x=4.5 MeV.

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