Gamow-Teller transitions in ^{37}Cl(^{3}He, t)^{37}Ar and ^{37}Ca→^{37}K β-decay

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The strengths of Gamow-Teller (GT) transitions B(GT) in $A = 37$ system are important physical quantities, because the deduced B(GT) values are used to calibrate the solar neutrino ^{37}Cl detector [1, 2]. The B(GT) values for the transitions $T_z = 3/2 \to 1/2$ and $T_z = -3/2 \to -1/2$ have been measured by a charge-exchange (CE) reaction ^{37}Cl(p, n)^{37}Al and ^{37}Ca $\to^{37}$ K β-decay work, respectively [3, 4, 5, 6, 7]. Under the assumption of isospin symmetry, GT strength distributions should be identical between $T_z = 3/2 \to 1/2$ and $T_z = -3/2 \to -1/2$ transitions. However these results showed significant differences. The (p, n) reaction study uses the assumption that the differential cross sections in CE reactions, like (p, n) or (^{3}He, t), are proportional to B(GT) values at momentum transfer $q \approx 0$ and at beam energy over ∼100 MeV/u [8, 9]. However it has been reported that this assumption is not necessarily universal for any target [8]. Additionally the resolution was poor to compare with the β-decay studies. In order to clarify the origin of the disagreements for the $A = 37$ nuclei, we performed a high-resolution ^{37}Cl(^{3}He, t) experiment.

A 140 MeV/u ^{3}He beam from the RCNP Ring Cyclotron was transported by the WS beam line [10]. The spectrometer Grand Raiden set at 0° was used for the momentum analysis of tritons. As a target, we used a thin foil of polyvinylidene chloride ([-CH$_2$-CCl$_2$-]$_n$) with 3.6 mg/cm^2 thickness. Figure 1 shows the 0° spectrum for the angular range $\leq$ 14 mr. With high energy resolution of 55 keV, fine structures were observed. However, the gross feature of this spectrum is quite similar to the 0°, ^{37}Cl(p, n) spectrum obtained at $E_p = 120$ MeV [6].

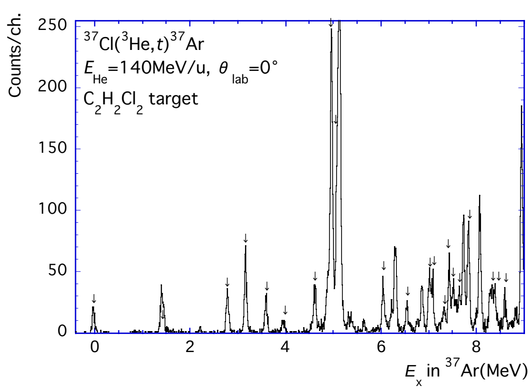

Figure 1: The ^{37}Cl(^{3}He, t)^{37}Ar spectrum at 0°. This spectrum include the contaminations of the states of ^{13}N and ^{35}Ar. Arrows indicate the states of ^{37}Ar.

In order to obtain B(GT) values from a CE experiment, a standard B(GT) value is needed. As the first choice, we used the B(GT) value from ^{37}Ar $\to$ ^{37}Cl, β-decay. The obtained B(GT) distribution is shown in Fig. 2(a), where the yields of excited states were corrected using the results of DWBA calculations. We find that the obtained distribution is rather similar with that of ^{37}Ca β-decay (Fig. 2(c)) up to $E_{\rm x} = 5$ MeV, but a significant disagreement is seen in the region $E_{\rm x} > 5$ MeV. It is suggested that the ground state is not suited for the overall normalization of B(GT) values. It has been reported that the transitions of the type $(j = l - \frac{1}{2}) \rightarrow (j = l - \frac{1}{2})$ may not follow the proportionality [8, 11].

In order to avoid the difficulty, another standard B(GT) was chosen. In the concept of one-particle one-hole transition based on the simple shell model, it is expected that the fraction of transition with the configuration $j_< j_<^{-1}$ become small in the highly excited region above IAS. Therefore, the sum of B(GT) values from the ^{37}Ca β-decay data in the highly excited region from 6.9 to 8.1 MeV was used as another standard. The result is shown in fig. 2(b). Naturally we find a significant discrepancies with the ^{37}Ca β-decay measurement in the region at $E_{\rm x} < 5$ MeV.

We consider two possible explanations for these discrepancies. (1) The proportionality between (^{3}He, t) cross section and B(GT) is not valid. (2) We have seen the isospin asymmetry in the transitions $T_{\rm z} = \frac{3}{2} \rightarrow \frac{1}{2}$ and $T_{\rm z} = -\frac{3}{2} \rightarrow -\frac{1}{2}$.

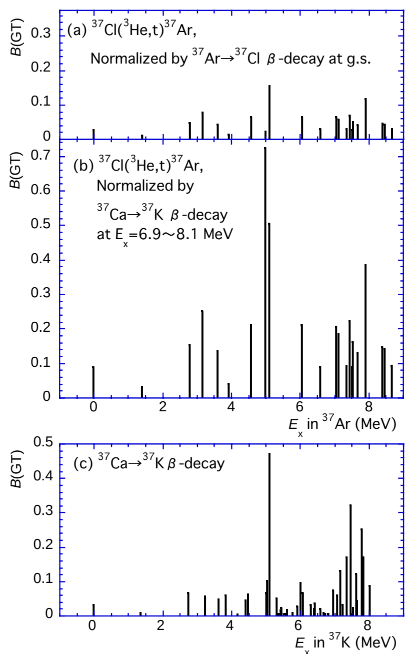

Figure 2: the B(GT) strength distributions of the ^{37}Cl $\rightarrow$ ^{37}Ar and ^{37}Ca $\rightarrow$ ^{37}K transitions measured by ^{37}Cl(^{3}He, t)^{37}Ar reaction and ^{37}Ca β decay. in Fig. (a), normalization standard is taken from the ^{37}Cl $\rightarrow$ ^{37}Ar β decay while in Fig. (b), it is taken from the 6.9−8.1 MeV region of the ^{37}Cl $\rightarrow$ ^{37}K β decay. for details, see text.

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