Gamow-Teller Transitions Observed in ^{25}Mg(^{3}He,t)^{25}Al Measurement

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The Gamow-Teller (GT) excitation caused by the $\sigma\tau$ operator is the simplest spin excitation without angular momentum transfer ($\Delta L = 0$), and, therefore, is associated with the $\Delta J^{\pi} = 1^{+}$ selection rule, where J^{π} denote the total spin and the parity. The GT states are selectively excited in β decays as well as in charge-exchange (CE) reactions at 0° and at intermediate incident energies [1]. In CE reactions under these experimental conditions, there is a proportionality between the cross sections and B(GT) values [2].

According to the $\Delta J^{\pi} = 1^{+}$ selection rule, GT transitions are allowed from the ground state of ^{25}Mg with $J^{\pi} = 5/2^{+}$ to the $J^{\pi} = 3/2^{+}$, $5/2^{+}$, and $7/2^{+}$ "GT states" in ^{25}Al. In Ref. [3], more than ten states with one of these J^{π} values are listed in the $E_x < 6$ MeV region. We studied the transition strengths to these states by using the (^{3}He,t) reaction at 0°.

A ^{25}Mg(^{3}He,t)^{25}Al experiment was performed at RCNP, Osaka by using a 140 MeV/nucleon ^{3}He beam from the $K = 400$, RCNP Ring Cyclotron and the Grand Raiden spectrometer [4]. A thin self-supporting ^{25}Mg target with a thickness of 0.93 mg/cm^2 was used. The isotopic enrichment of ^{25}Mg was 98.3%. The outgoing tritons were momentum analyzed within the full acceptance of the spectrometer. The acceptance of the spectrometer was subdivided in the software analysis by using the track information.

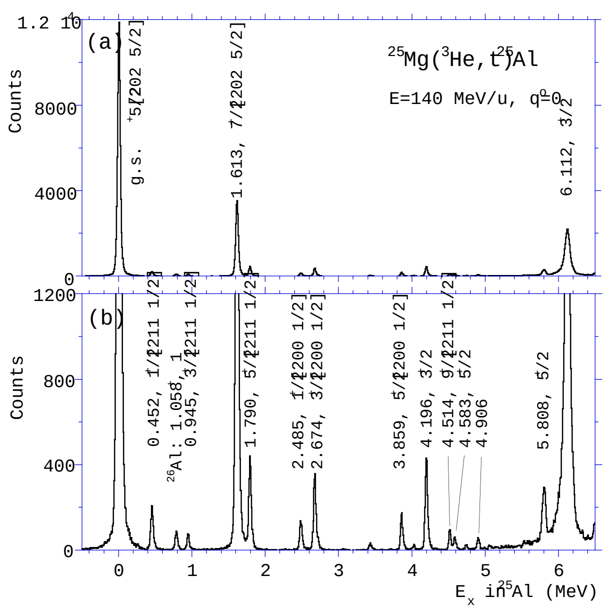

Figure 1: The 0°, ^{25}Mg(^{3}He,t). The major GT states are indicated by their excitation energies. A "desert region" was observed in the $E_x = 2-6$ MeV region.

An energy resolution far better than the energy spread of the beam was realized by applying *dispersion matching* and *focus matching* techniques [5]. In order to realize these matching conditions, the high-resolution "WS course" [6] for the beam transportation and the "faint beam method" [7] to diagnose the matching conditions were utilized. In the present measurement, a very good energy resolution of 35 keV [full width at half maximum (FWHM)] was achieved. With this improved resolution, states up to $E_x = 6$ MeV were clearly resolved, as shown in Fig. 1. Many of these states are so weak that they can be seen only with an expanded vertical scale.

In order to obtain $B(\mathrm{GT})$ values by using the proportionality between the cross sections at 0° and the $B(\mathrm{GT})$ values, a standard $B(\mathrm{GT})$ value is needed. We used the $B(\mathrm{GT})$ value of 0.165 ± 0.007 obtained in the β-decay from the ^{25}Al ground state to the 1.612 MeV state of ^{25}Mg (see table 1 and ref. [3]). If isospin symmetry of mirror nuclei is assumed, it is expected that the $B(\mathrm{GT})$ values of mirror transitions are the same. We postulated that the transition to the 1.613 MeV state in ^{25}Al have this $B(\mathrm{GT})$ value in the $^{25}\mathrm{Mg}(^3\mathrm{He}, t)$ reaction. The $B(\mathrm{GT})$ values for other excited GT states can be calculated by using the proportionality from their peak counts at 0°. Results of distorted wave Born approximation (DWBA) calculations were used to correct for the E_x dependence of the proportionality coefficient. The resulting $B(\mathrm{GT})$ values including this correction of up to 6% are listed in Table 1. Since both $\sigma\tau$ and τ operators contribute in the transition between ground states, a separate extraction of the GT strength is not possible from the present $(^3\mathrm{He}, t)$ measurement. Therefore, the $B(\mathrm{GT})$ value from the mirror symmetry β decay is given for the ground state. As we see, except for the ground state, 1.613 MeV, and 6.122 MeV states, the $B(\mathrm{GT})$ values are very small. As mentioned, the $B(\mathrm{GT})$ values < 0.04 are expected to be less reliable.

Table 1: Low-lying states in ^{25}Al with $J^\pi = 3/2^+$, $5/2^+$, and $7/2^+$. The GT transition strengths $B(\mathrm{GT})$ from the $^{25}\mathrm{Mg}(^3\mathrm{He}, t)^{25}\mathrm{Al}$ reaction are listed.

States in ^{25}Al		
$E_x(MeV)^{(a)}$	$2 \cdot J^{\pi(a)}$	$B(\mathrm{GT})$
0.0	5^+	$0.408(2)^{(b)}$
0.945	3^+	$0.003(1)^{(f)}$
1.613	7^+	$0.165(7)^{(b,d)}$
1.790	5^+	$0.019(2)^{(c)}$
2.674	3^+	$0.017(2)^{(c)}$
2.720	7^+	
3.859	5^+	$0.007(1)^{(c)}$
4.196(3)	3^+	$0.019(2)^{(c)}$
4.583(4)	5^+	$0.002(1)^{(c)}$
4.906(4)	7^+	
5.808(6)	5^+	$0.020(4)^{(c)}$
6.122(3)	3^+	0.235(29)

(a) From ref. [3].
(b) $B(\mathrm{GT})$ value from β-decay measurement.
(c) Obtained $B(\mathrm{GT})$ value is small and less reliable, see text.
(d) $B(\mathrm{GT})$ value used as a standard.

References

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