High-resolution study of ^{11}B to ^{11}C Gamow-Teller strengths

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The most direct information on the GT transition strength $B(\mathrm{GT})$ is obtained from β-decay studies, but the accessible range of excitation energy (E_x) is limited by the small Q value for the $A = 11$ system ($Q_{\mathrm{EC}} = 1.98$ MeV). In the β-decay study of ^{11}C, the $B(\mathrm{GT})$ value can be obtained only for the g.s. to g.s. transition. Charge-exchange reactions, like the (p, n) reaction, can access analogous GT transitions without the Q-value limitation. In particular, those performed at angles around 0° and intermediate energies ($E_p > 100$ MeV) were shown to be good probes of GT transition strengths owing to the relatively simple proportionality between the cross sections at 0° and the $B(\mathrm{GT})$ values [1],

$$\frac{d\sigma_{\mathrm{CE}}}{d\Omega}(0^\circ) \simeq K\, N_{\sigma\tau}\, |J_{\sigma\tau}(0)|^2 B(\mathrm{GT}) = \hat{\sigma}_{\mathrm{GT}}(0^\circ) B(\mathrm{GT}), \tag{1}$$

where $J_{\sigma\tau}(0)$ is the volume integral of the effective interaction $V_{\sigma\tau}$ at momentum transfer $q = 0$, K is a kinematic factor, $N_{\sigma\tau}$ is a distortion factor, and $\hat{\sigma}_{\mathrm{GT}}(0^\circ)$ is a unit cross section for the GT transition at 0°.

The ^{11}B(^{3}He$, t)^{11}$C experiment was performed at the high energy-resolution facility of RCNP, consisting of the "WS course" and the Grand Raiden spectrometer using a 140 MeV/nucleon ^{3}He beam from the $K = 400$ Ring Cyclotron [2]. An energy resolution of 45 keV (FWHM) was achieved. By consulting Ref. [3], all of these prominent states could be identified as ^{11}C states with J^π values of either $1/2^-, 3/2^-$, or $5/2^-$, i.e., the J^π values allowed by the GT transitions. No broadening of peak widths was observed for these states.

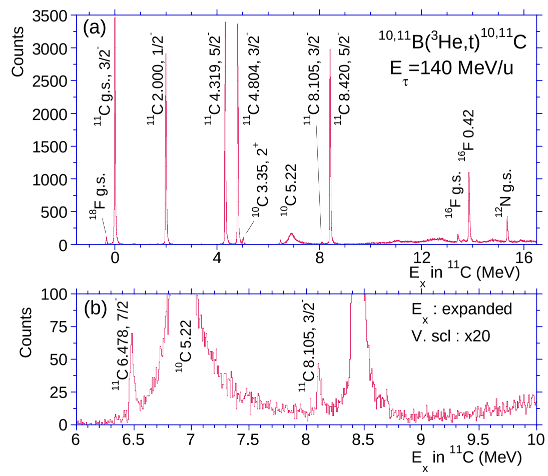

Figure 1: Spectra of the ^{11}B(^{3}He$, t)^{11}$C reaction of (a) the range up to the excitation energy of 16 MeV for scattering angles $\Theta \leq 0.5^\circ$, and (b) expanded $6 - 10$ MeV region. Excitation energies (in MeV) and J^π values are indicated. Weakly excited $3/2^-$ state was observed at $E_x = 8.105$ MeV. Although the GT transition to this state is J^π allowed, the transition strength is very weak, suggesting a completely different structure compared to the other strongly excited states.

In the earlier (p, n) experiments [4], one broad peak was observed at 4.5 MeV. This peak was resolved into two sharp states at 4.319 and 4.804 MeV with nearly equal strengths. A previously unresolved peak at 8.4 MeV was also resolved into 8.105 and 8.420 MeV states in agreement with Ref. [3]. It was found that there was almost no strength in the transition to the $J^\pi = 3/2^-$, 8.105 MeV state, although the transition from the ^{11}B g.s. with $J^\pi = 3/2^-$ is allowed by the J^π selection rule. Recently, a calculation using AMD method showed that this state can have a cluster structure with 2α+^{3}He [5].

For details see Ref. [6].

References

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