The Gamow Teller distribution in ^{14}O using the ^{14}N(^{3}He,t)^{14}O reaction

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Although all the quantum numbers involved in the β decay of ^{14}C and ^{14}O to the ground state of ^{14}N (J^π=1$^+$, T=0) suggest an allowed Gamow Teller (GT) character, these transitions are strongly suppressed [1]. In order to understand this well known anomaly, we investigated the GT strength distribution from the ground state of ^{14}N to levels in ^{14}C and ^{14}O. Shell Model calculations performed by S. Aroua *et al.* [2] predict that the structure of the ground state of ^{14}N explaining the hindrance of the GT decays between the ground states of ^{14}C and ^{14}O and the ^{14}N ground state favors the transition to one single 2$^+$ state rather than to the 0$^+$ or 1$^+$ excited states in the final nuclei.

In order to overcome the Q-value limitation of the energy range that can be investigated in the β-decay studies, one has to employ (n,p) and (p,n) type charge-exchange (CE) reactions for the determination of the GT strength distributions in final nuclei. It is known that the 0° cross sections of hadron CE reactions performed at intermediate energies exceeding 100 MeV/nucleon are essentially proportional to the B(GT) values observed in β-decays [3]. This is because of the simplicity of the reaction mechanism and the dominance of the interaction $V_{\sigma\tau}$ with the $\sigma\tau$-type operator at small momentum transfer [4]. Further on, in order to achieve a good resolution and to allow the accurate determination of the GT strength to each individual level, one has to use (^{3}He,t) and (d,^{2}He) reactions instead of (p,n) and (n,p).

A ^{14}N(^{3}He,t)^{14}O experiment performed at RCNP addressed the question of the GT distribution in the β^- direction. A 1.2 mg/cm^2 melamine ($C_3H_6N_6$) target was used. The 420 MeV ^{3}He beam from the Ring Cyclotron was tuned with the WS high-resolution beam line. The outgoing tritons were angle and momentum analyzed by the Grand Raiden spectrometer and the focal plane detection system. Applying the momentum and angular beam matching techniques together with the overfocus mode [5], an energy resolution of about 35 keV was obtained. Data were taken at 0° and 2.5° settings of the spectrometer. This will allow the determination of the angular distributions and the identification of the the transitions carrying GT strength.

The obtained spectrum is presented in Fig. 1. The presence of ^{12}C in the target did not affect the ^{14}O spectrum in the region of interest where the GT strength is expected [2] (E_x(^{14}O) <12 MeV) but will provide a calibration for the extraction of the B(GT) values. Also the other constituents of the target did not affect the ^{14}O spectrum (see Fig. 1). The very good energy resolution obtained in this experiment allows, as a supplementary result, the determination of the natural widths of several excited states in ^{14}O (S_p=4.628 MeV).

As can be seen in Fig. 1, the ground state → ground state transition is strongly hindered and the strength is going mainly to three 2$^+$ excited states as the theoretical calculations [2]

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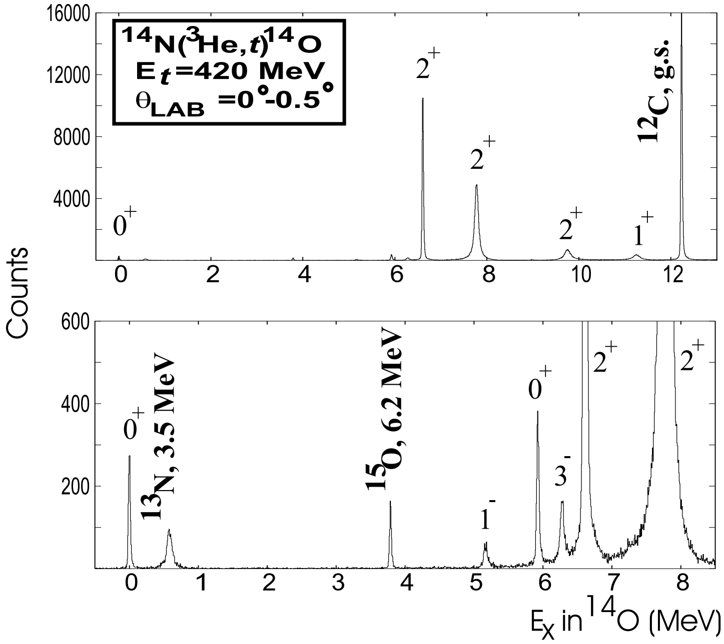

Figure 1: The (^{3}He,t) spectrum of the melamine target. The upper panel represents the full spectrum, while the lower one contains a zoomed spectrum of the E_x=0-8 MeV region. The transitions to ^{12}N, ^{13}N and ^{15}O due to the other components of the melamine target are indicated.

predicted.

The odd-odd nucleus ^{14}N has $N = Z$ and ^{14}O and ^{14}C are mirror nuclei. By comparing ^{14}N(^{3}He,t) spectrum with that of a mirror experiment ^{14}N(d,^{2}He)^{14}C [6] performed at KVI, Groningen, a striking similarity was found, suggesting a good isospin symmetry for the $A = 14$ system. From this comparison, we can suggest that the J^π values of the 9.715 MeV and 11.240 MeV states in ^{14}O are 2^+ and 1^+, respectively (see Fig. 1, upper panel).

Although the strength mainly goes to the 2^+ states, in agreement with the theory [2], an open question remains for the observed fragmentation of the GT strength over three 2^+ excited states. Since two of the three strongly excited 2^+ states that exist (see Fig. 1 and Ref. [1]) in the $6 - 8$ MeV region of ^{14}O and also in ^{14}C cannot be described in the shell model, alternative nuclear models should be considered. Recently, Itagaki *et al* [7] described the ^{14}C nucleus by assuming an equilateral-triangular structure of three alpha clusters surrounded by two excess neutrons. They predict three 2^+ states as the excited states on three $K^\pi = 0^+$ rotational bands. It is very interesting to see if the observed GT strength distribution can be explained in such a framework.

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