Spin-isospin response of the neutron-rich nucleus ^{8}He via the (p, n) reaction in inverse kinematics

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Charge-exchange (p, n) reactions at intermediate energies ($E > 100$ MeV) serve as powerful tools to study spin-isospin responses of nuclei; Gamow-Teller (GT) transitions are a particular example of such reactions. In the present work, we focused on the neutron-rich nucleus ^{8}He, which has the largest neutron-to-proton ratio among all known particle-stable nuclei ($N/Z = 3$). It can be described as an α-particle surrounded by four valence neutrons, exhibiting a neutron halo or thick neutron skin. We measured the ^{8}He$(p, n)^8$Li reaction at 190A MeV in inverse kinematics in order to study the spin-isospin response of ^{8}He. This is the first measurement of the charge-exchange reaction on ^{8}He.

The experiment was performed at the RIKEN RI Beam Factory (RIBF). Recoil neutrons with low kinetic energies from the (p, n) reactions were detected by the recently developed neutron detector WINDS.[1)] The residual nucleus ^{8}Li and its decay product ^{7}Li were detected using auxiliary beam line detectors, a plastic scintillator, and a multi-wire drift chamber (LP-MWDC)[2)], installed at FH10, which is downstream from the secondary target at FH9. A superconducting triplet quadrupole (STQ) was installed between FH9 and FH10. The triton decay channel of the excited state in ^{8}Li was not tagged in this measurement.

Double differential cross sections for the ^{8}He$(p, n)^8$Li reaction at excitation energies of 0–20 MeV and neutron energies of 2.0–4.4 MeV, which correspond to momentum transfers of 0.31–0.46 fm^{-1}, were obtained. Figure 1 shows the double differential cross sections for T_n = 2.0–2.6 MeV, corresponding to q = 0.31–0.35 fm^{-1}. In the spectrum, two peaks were observed at $\sim$ 1 MeV and $\sim$ 8 MeV. The lower peak corresponds to the first excited 1^+ state of ^{8}Li at 0.98 MeV.

The angular distributions of the cross sections for the peaks at $\sim$ 1 MeV and $\sim$ 8 MeV are shown in Fig. 2. In this figure, the differential cross sections were corrected for the transmission efficiencies between FH9 and FH10. They were compared to the results of distorted wave impulse approximation (DWIA) calculations. The angular distribution of the peak at $\sim$ 1 MeV, which is a flat distribution, was reproduced well by the sum of the 0.98-MeV state ($J^\pi = 1^+$) and the ground state ($J^\pi = 2^+$). The cross sections at $q = 0$ for the 0.98-MeV and 8-MeV states were extracted. We then calculated the GT strength B(GT) for the 8-MeV state by using the extracted cross sections at $q = 0$ and the known B(GT) value of 0.24 for the 0.98-MeV state. The obtained GT strength was B(GT) $\sim$ 8 for the neutron decay channel of the 8-MeV state.

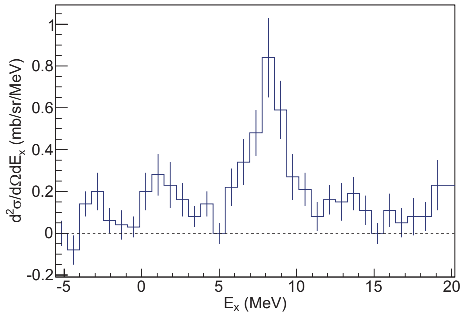

Fig. 1. (Preliminary) Double differential cross sections for T_n = 2.0–2.6 MeV.

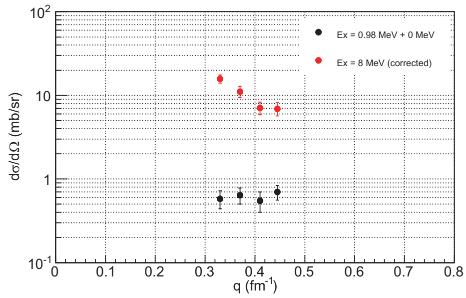

Fig. 2. (Preliminary) Angular distributions of the measured cross section for the 0.98-MeV (black) peak and the 8-MeV (red) peak.

It is known that the excited state at $\sim$ 9 MeV with a large GT strength of B(GT) $\sim$ 5 decays primarily by triton emission.[3,4)] In contrast, we observed, for the first time, a neutron decay channel of the resonance state with a large B(GT) strength. This result suggests that most of the GT strength is concentrated in the resonance state at $\sim$ 8 MeV. The observed state is most likely the Gamow-Teller resonance of ^{8}He. Further analysis is in progress.

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