Spin-dipole response of $^4$He by using ($^8$He, $^8$Li(1+))


The spin dipole ($\Delta S = \Delta L = 1$) of spin-isospin responses is connected with the tensor correlation in nuclei. Especially, on a double-closed nucleus, the SD excitation contribution is large because of the nucleon configuration. The SD excitation function was measured on $^4$He which is the lightest double-closed nucleus. This is important for the study of supernova nucleosynthesis with the neutrino-nucleus reaction\(^1\).

We conducted the exothermic charge-exchange (CE) reaction of $^4$He($^8$He, $^8$Li(1+))$^4$H. CE reactions are powerful tools to study the spin-isospin responses. The spin-flip transition of $^8$He(0+) $\rightarrow ^8$Li(1+) can be identified by measuring the de-excited $\gamma$-rays ($E_\gamma = 0.98$ MeV) from the first $1^+$ state of $^8$Li. The beam energy region of 100–300 MeV/nucleon is suitable for the study of the spin-isospin responses\(^5\).

The experiment was performed at the RIKEN RIBF facility by using BigRIPS\(^5\), the high-Resolution beamline\(^5\), and the SHARAQ spectrometer\(^5\). The $^8$He beam, which was produced via a projectile-fragmentation reaction with an $^{18}$O beam and $^8$Be target, was transported to the secondary target position at an intensity of 2 MHz. We used the liquid-$^4$He target\(^6\) with a thickness of 120 mg/cm\(^2\). In order to determine the excitation energy using missing mass method, the momenta of $^8$He and $^8$Li at an energy of 100 MeV/nucleon were measured at the beamline and SHARAQ within the low-pressure multi-wire drift chamber (LP-MWDC)\(^7\) and cathode readout drift chamber\(^8\). The $\gamma$-ray detector array DALT2\(^2\) was placed around the target position to measure the 0.98 MeV $\gamma$-ray.

Figure 1 shows the missing mass spectrum of the ($^8$He,$^8$Li) reaction (black line). The contribution of both the $^4$He target and hydrogen is included in this spectrum. The region around 10 MeV and $\sim$17 MeV shows the $^4$He $\rightarrow ^4$H and $^1$H $\rightarrow n$ reactions, respectively. The $^1$H $\rightarrow n$ reaction originates at the plastic scintillator installed at the upstream of the target. The amount of contamination (red line) was estimated by using the energy loss of the LP-MWDC placed between the scintillator and the target. Thus, the $^4$He($^8$He, $^8$Li)$^4$H reaction was obtained.

Further analysis to obtain the angular distribution and double differential cross-sections is now in progress to obtain the isovector SD strength of $^4$He.

References