Neutron-neutron correlation in Borromean nucleus $^{11}\text{Li}$ via the \((p, pn)\) reaction


Since a theoretical prediction was made by Migdal,*1 a hypothetical bound state of two neutrons, dineutron, has attracted much attention. The neutron-neutron correlation caused by the dineutron is expected to appear in weakly bound systems, such as the Borromean nucleus $^{11}\text{Li}$. There have been extensive studies to search for such a correlation in $^{11}\text{Li}$. $E1$ strengths deduced from Coulomb dissociation cross sections have been used by employing the $E1$ cluster sum rule to characterize their correlation.2 However, the model dependence was not negligible owing to the $^9\text{Li}$ core excitation and the final-state interactions.3 The kinematically complete measurement of the quasi-free \((p, pn)\) reaction was thus performed with Borromean nuclei $^{11}\text{Li}$, $^{14}\text{Be}$, and $^{17,19}\text{B}$ at the RIBF so as to determine the neutron momentum distributions that provide more direct information of the ground-state correlation.4

The measurement required a high luminosity to have as much statistics as possible. For this purpose, the 15-cm-thick liquid hydrogen target MINOS5 was introduced. The SAMURAI spectrometer5 contributed to minimize experimental biases originating from the geometrical acceptance. A missing-mass setup composed of the neutron detector WINDS,7 the recoil proton detector RPD, and the gamma-ray detector array DALI25 was newly configured for realizing the quasi-free \((p, pn)\) measurement.

As a measure of the dineutron correlation in $^{11}\text{Li}$, the opening angle of two valence neutrons $\cos \theta_Y$ was reconstructed from momentum vectors of all the particles involved in the reaction. The obtained $\cos \theta_Y$ distribution is shown in Fig. 1. The geometrical acceptance of the experimental setup was corrected by performing a Monte-Carlo simulation. The asymmetric distribution indicates an admixture of different parity states and the dineutron correlation in $^{11}\text{Li}$. The asymmetry obtained in the present work is weaker than that in the previous work employing the neutron removal reaction by using a carbon target.9 We presume that the dineutron correlation was overestimated in the previous study because of the sensitivity of the probe; the probe used in the previous study is only sensitive to the nuclear surface, where the dineutron correlation is expected to develop.

![Fig. 1. Opening-angle distribution $\cos \theta_Y$ for $^{11}\text{Li}$. The blue open and black closed marks represent the data taken in the present and previous works.](image)

References