Determination of a dineutron correlation in Borromean nuclei via a quasi-free knockout (p, pn) reaction

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The two-neutron halo structure observed in ^{6}He, ^{11}Li, etc. is one of the most interesting topics in neutron-rich nuclei. It has been shown that the correlation between halo neutrons in the ground state is characterized as a spatially correlated neutron pair, the so-called dineutron.

The knockout reaction is an useful tool to investigate the ground-state structure of nuclei. In fact, for two-neutron halo nuclei, ^{11}Li and ^{14}Be, the one-neutron knockout reaction has been employed [1]. In Ref. [1], although the contributions of the S- and P-states were discussed using the angular distributions of the emitted neutrons, the dineutron correlation is not discussed. Thus, it should be of interest to discuss the dineutron correlation from the angular distribution of the knocked-out neutron from the two-neutron halo nuclei.

The purpose of this work is to investigate the possibility of extracting information about the dineutron correlation in ^{6}He by means of the proton-induced neutron knockout reaction. To discuss the spatial correlations, we consider the quasi-free condition to minimize the final-state interaction (FSI) in the knockout reaction. In particular, it is important to minimize the effect of the knockout process via the ^{5}He resonance to discuss the dineutron correlation in ^{6}He. In this work, we estimate the effect of the process via the ^{5}He resonance on the angular distributions and try to elucidate the kinematical condition that excludes the contribution from the knockout process via the ^{5}He resonance.

We employ a simple reaction model [2] in the present calculation and calculate the $\mathcal{T}$-matrix for the quasi-free (p,pn) reaction as follows.

$$\mathcal{T} = \left\langle \psi_{\alpha\text{-}n}(\mathbf{k}, \mathbf{r}) \otimes e^{i\mathbf{K}\cdot\boldsymbol{\rho}} \left| e^{i\mathbf{q}\cdot\boldsymbol{\rho}} \right| \Phi_{^6\mathrm{He}}(\mathbf{r}, \boldsymbol{\rho}) \right\rangle, \quad (1)$$

where $\psi_{\alpha\text{-}n}$ is the exact scattering wave function of the $\alpha + n$ system and $\Phi_{^6\mathrm{He}}$ is the ground-state wave function of ^{6}He, which is solved in the $\alpha + n + n$ three-body model. We here assume the following two points: (i) The knocked-out neutron is free from FSI and its motion is described by a plane wave. (ii) The knockout process is treated by a simple momentum transfer operator with transferred momentum $\mathbf{q}$.

Using the $\mathcal{T}$-matrix in Eq. (1), we calculate the angular distributions in knockout reaction as shown in Fig. 1 and compare it with the ground-state distributions. Here, the correlation angle θ is defined by $\mathbf{k} \cdot (\mathbf{K} - \mathbf{q}) = k|\mathbf{K} - \mathbf{q}| \cos\theta$. To obtain the results in Fig. 1, we choose the off-resonant relative momentum of $\alpha + n$ as 0.1 and 0.4 fm^{-1}, which are respectively smaller and larger than that corresponding to the ^{5}He$(3/2^-)$ resonance. By gating on the α-n relative momentum, the asymmetric shapes in the angular distributions are similar to those in the ground state. This fact shows that it is essential to choose the kinematical condition to exclude the process via the ^{5}He resonance when discussing the dineutron correlation by the knockout reaction.

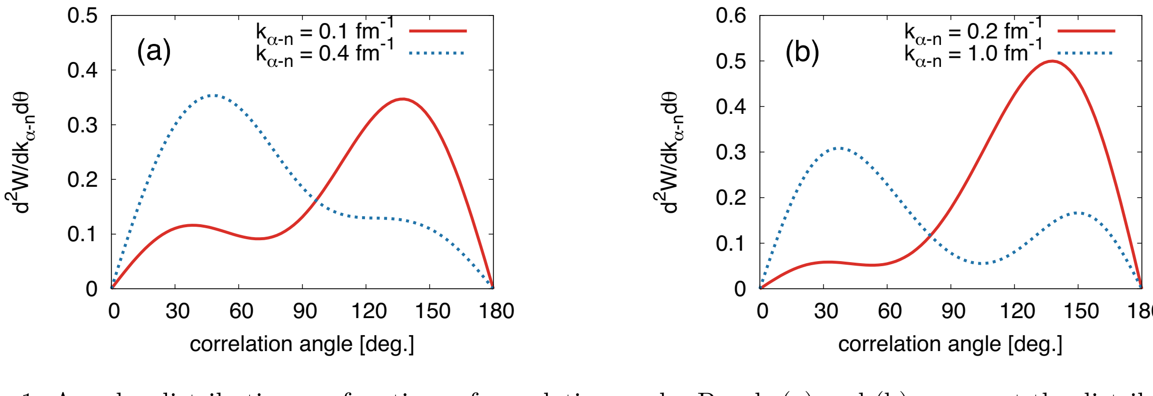

Figure 1: Angular distributions as functions of correlation angle. Panels (a) and (b) represent the distributions in the (p,pn) reaction and those in the ground state, respectively.

References

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