Asymmetry of the parallel momentum distribution of (p,pN) reaction residues

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The shape of the parallel momentum distribution (PMD) of (p,pN) reaction calculated with the Glauber model is restricted to being symmetric. On the other hand, in some cases the observed PMD shows quite large asymmetry [1, 2, 3]. It will be interesting and important to clarify the mechanism of the asymmetry of the PMD. The contents of this report have been published [4].

The PMD of the residual nuclei of the ^{14}O$(p,pn)^{13}$O and ^{14}O$(p,2p)^{13}$N reactions at 100 and 200 MeV/nucleon in inverse kinematics is investigated. An eikonal DWIA model was adopted, which was shown to reproduce the TDX data of the ^{12}C$(p,2p)^{11}$B at 392 MeV very well. As shown in Fig. 1(a), the PMD of both ^{13}O and ^{13}N have an asymmetric shape at 100 MeV/nucleon. The high momentum side steeply falls, whereas a well-developed tail exists on the low momentum side.

The former is, As shown in Fig. 1(b), found to be due to the phase volume effect reflecting the energy and momentum conservation. The width Γ of the PMD is much smaller than that of the single particle (s.p.) momentum distribution (MD) by the phase volume effect. This should be remarked because Γ is used as a measure of the s.p. orbital angular momentum l. On the other hand, the phase volume does not change the peak height of the PMD. The phase volume effect becomes less important when the separation energy of the knocked-out nucleon S_N is small because 1) the cutoff momentum of the phase volume on the high momentum side is large and 2) the width of the s.p. MD is small.

The latter, the tail of the PMD on the low momentum side, is found to be due to the momentum shift of the outgoing two nucleons inside an attractive potential caused by the residual nucleus, as shown in Fig. 1(c). Consequently, the PMD probes the nucleon inside the nucleus A having the larger longitudinal momentum than the asymptotic one due to the distortion effect. It should be noted that this effective acceleration gives a somewhat large reduction of the peak height of the PMD, which is a key quantity to determine the spectroscopic factor $\mathcal{S}$. The momentum shift has a quite small effect ($\sim 5\%$) on the integrated cross section.

We found that at 200 MeV/nucleon the phase volume effect becomes less important, whereas the distortion effect still exists. For the ^{31}Ne$(p,pn)^{30}$Ne reaction at 200 MeV/nucleon, exceptionally, the PMD has an almost symmetric shape. This is because of the very small value (0.15 MeV) of S_N in this case. It should be remarked that the small distortion effect is due to the halo structure of ^{31}Ne; the contribution of the nuclear interior region, where distorting potentials are large, to the (p,pN) transition amplitude is almost negligible.

Extension of the present DWIA framework to knockout reactions by a nucleus will be important for discussing various experimental data of nucleon removal processes measured so far. See Ref. [4] for more detail.

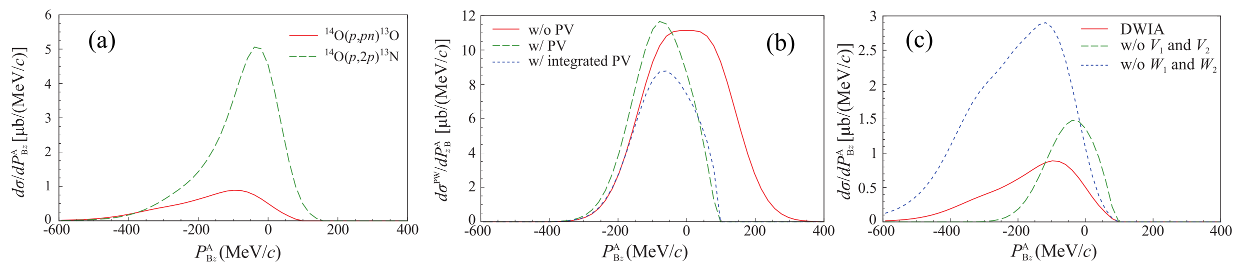

Figure 1: Parallel momentum distribution of
(a) the ^{14}O$(p,pn)^{13}$O (solid line) and ^{14}O$(p,2p)^{13}$N (dashed line) reaction residues at 100 MeV/nucleon.
(b) the ^{14}O$(p,pn)^{13}$O reaction residue at 100 MeV/nucleon. The solid (dashed) line is the PWIA result without (with) the phase volume (PV). The dotted line is the same as the dashed line but an averaged PV is used.
(c) ^{13}O for ^{14}O$(p,pn)^{13}$O at 100 MeV/nucleon in inverse kinematics. The solid line is the DWIA result, whereas the dashed (dotted) line represents the result calculated with $V_i = 0$ ($W_i = 0$) for particles 1 and 2.

References

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