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Reaction model for a correct understanding of the (p,pd) reaction

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In the experiment performed 40 years ago at the University of Maryland, it was reported that the cross section of the $^{16}\mathrm{O}(p,pd)^{14}\mathrm{N}$ reaction [1] is almost half that of the $^{16}\mathrm{O}(p,2p)^{15}\mathrm{N}$ reaction [2]. This result may indicate that the existence probability of the deuteron in $^{16}\mathrm{O}$ is surprisingly high and that there are pn correlation including the deuteron "cluster." To describe this reaction, it is important to treat the fragility of the deuteron properly. The deuteron can be easily broken up by the incident proton in the elementary process. In addition, the knocked-out deuteron is expected to go through transition between the bound and breakup states by the final-state interactions (FSIs). Furthermore, the deuteron broken up in the elementary process can reform a deuteron by the FSIs. These processes are not included in the distorted wave impulse approximation (DWIA) framework [3], which is the standard reaction model for describing the knockout reactions as employed in the (p,pd) analysis of Ref. [2]. Therefore, even if measurement results of deuteron knockout reactions are systematically obtained, it is not possible to conclude clearly whether deuterons exist in nuclei or not by the DWIA analysis. Thus, a reaction model beyond DWIA is necessary.

In this presentation, we are going to report the numerical results calculated with such a reaction model, CDCCIA, which we have been constructing [4]. In CDCCIA, the elementary processes of the (p,pd), i.e., the p-d elastic scattering and the $d(p,p)pn$ reaction, are described with an impulse picture employing a nucleon-nucleon effective interaction. In addition, the three-body scattering waves in the final state of the (p,pd) reaction are calculated with the continuum-discretized coupled-channels method (CDCC) [5–7]. We will shown that the deuteron reformation significantly changes the explicit cross section of the (p,pd) reaction through the interference between the elastic and breakup channels of deuteron. Our conclusion is that including these processes is important to quantitatively discuss the (p,pd) cross sections in view of the deuteron formation in nuclei.

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