Multiple mechanisms in proton-induced nucleon removal at ∼100 MeV/nucleon[†]

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Nucleon-nucleon correlations are essential to describe nuclear properties. From $(e, e'p)$ experiments on stable nuclei, it was revealed that the nuclear single-particle strengths is reduced by 30–40% relative to the independent particle model.[1)] This quenching is described by the reduction factor $R_S = \frac{\sigma_{\rm exp}}{\sigma_{\rm th}}$, which has been systematically studied with one-nucleon removal reactions at intermediate energies based on the Fermi-surface asymmetry,[2–5)] with results varying across different reaction models. At intermediate energies, the eikonal reaction model is widely adopted, which predicts a symmetric parallel momentum distribution (PMD) of the residue. However, asymmetric PMDs found in various experiments suggest that additional effects need to be considered.[5)]

This study reports the first one-nucleon removal from a large Fermi-surface asymmetric nuclei ^{14}O ($\Delta S = \pm 18.6$ MeV) at ∼100 MeV/nucleon with a proton target. The experiment was performed at the SAMURAI spectrometer, where the momentum of the reaction residues ^{13}O and ^{13}N were measured.

Figures 1(a) and (b) demonstrate that the sum of the $(p, 2p)$ and (p, p') PMDs are close to symmetric and reproduce the PMD of ^{13}N well. The fractional contribution of the inelastic component is 51% with the DWIA (Distorted-Wave Impulse Approximation)[6)] and 43% with the QTC (Quantum Transfer-to-the-Continuum).[7)] The reduction factors are $R_S = 0.6$ and $R_S = 0.51$. If the inelastic component is ignored, R_S is around unity, coinciding with the loosely bound nucleon removal R_S from eikonal model based analysis.

For the deeply bound neutron removal, (p, d) is considered in the QTC but not in the DWIA formalism. Single-channel transfer calculations for the (p, d) channel agree with the cross sections from QTC, and when added to DWIA, they reproduce the PMD of ^{13}O well, as shown in Fig. 1(c). The reduction of the theoretical prediction occurs at $R_S = 0.49$ and (p, d) contributes approximately 30%. The low momentum tail is caused

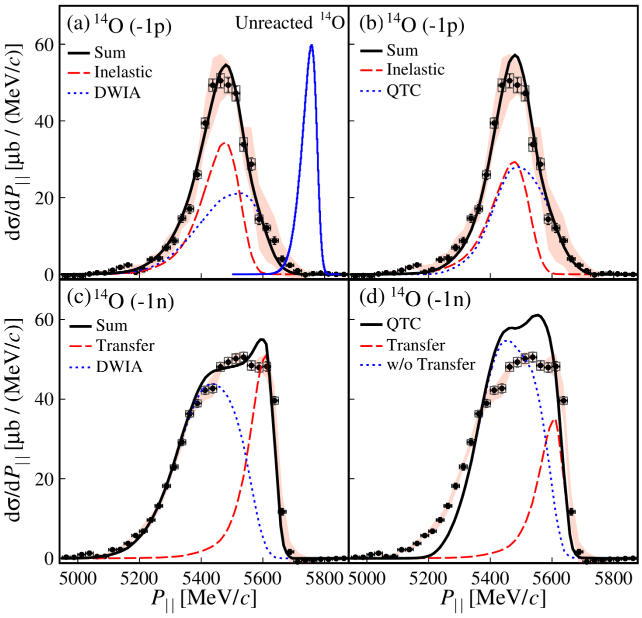

Fig. 1. Experimental momentum distributions of ^{13}N and ^{13}O in comparison with theory. Theoretical distributions have been normalized to the experimental data.

by the attractive potential between the outgoing nucleons and ^{13}O.[6)] The transfer reaction creates a sharp high-momentum edge, which is in a kinematic region inaccessible to knockout reactions, and thus a proof for the transfer contribution, which is generally neglected at such energies. Since the QTC formalism treats (p, d) consistently with (p, pn), it reproduces the sharp high-momentum side better, as shown in Fig. 1(d). However, the low-momentum tail is not reproduced, which could be due to different treatment of the final state interaction. The calculated reduction is $R_S = 0.34$.

In summary, inelastic scattering and the transfer reaction mechanisms should be assessed for one-nucleon removal reactions at intermediate energies. Further studies should clarify the impact of the transfer contribution based on the incident beam energy.

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