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Study of Neutron-Proton Correlations & 3N Forces in 12C

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Obtaining direct information on neutron-proton (np) correlations in nuclei is a long-sought goal in nuclear physics. Two-nucleon knockout reactions offer a powerful tool as the reaction cross section is a direct probe of nucleon correlations. The available experimental data with 12C incident on a C target at 1.05 and 2.10 GeV/u shows that the inclusive cross sections from np removal channel is 5~8 times greater than those for 2n (to 10C) and 2p pairs (to 10Be) [1,2], in excess of the ratio 16/6~2.7 from simple pair counting in 12C. Such enhancement however could not be described by the calculations using eikonal reaction dynamics and structure from the effective-interaction shell model and the no-core shell model (NCSM) [3].

To further investigate the nature of nucleon correlations and the origin of discrepancy between the observations and theories, we have performed the first final-state exclusive np-removal cross section measurements using DALI2 gamma-detection array and SAMURAI spectrometer at RIKEN. By the gamma-residue and gamma-residue-neutron coincidence technique, the partial cross sections to 10B and 10Be T=0 and T=1 final sates following np and pp removal from 12C at 190 MeV/u were extracted. The large ratio (5~8) of the np- to pp-removal cross section mentioned above was found to be mis-interpreted due to the ignorance of the particle-evaporation channels in the data. Our work reveals that the ratio is only 3.5(3) and could be well described by the NCSM approach with the inclusion of 3N forces. In addition, the NCSM calculations also provide an overall good agreement with the measured exclusive cross sections to both T=0 and T=1 states of 10B and 10Be, at variance with the conventional p-shell shell-model calculations which systematically underestimate the cross sections to the T=0 states. This study (i) reveals significant particle-evaporation contribution to the reaction yield of 10B, (ii) gains new insight into the importance of the 3N forces, and (iii) suggests insufficient treatment of the T=0 np correlations in the adopted p-shell shell model.

References

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[3] E. Simpson P. Navrátil, R. Roth, and J. A. Tostevin, Phys. Rev. C 86, 054609 (2012).

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