Probing three-nucleon-force effects via knockout reactions

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Three-nucleon-forces (3NFs) play an important role in few-nucleon systems, finite nuclei, and nuclear matter. In this work, we propose to use knockout reactions (p,2p) from a deeply bound orbit as a new probe into three-nucleon-force (3NF) effects. This reaction is suitable for studying effective nucleon-nucleon interactions since (p,2p) reactions at intermediate and high incident energies can be regarded as two-proton quasi-elastic scattering in the nuclear medium. The effective nucleon-nucleon interaction may be affected by 3NF effects at high density. We analyze (p,2p) reactions on a ^{40}Ca target within the framework of distorted-wave impulse approximation with a g-matrix interaction based on chiral two- and three-nucleon forces. In the framework, the 3NF effects are represented through the density-dependence of the g-matrix interaction. We elucidate the roles of 3NF effects through the density dependence of the g-matrix and demonstrate the possibility of probing 3NF effects via knockout reactions.

In Figure. 1, we show the triple differential cross sections of ^{40}Ca(p,2p)^{39}K at the incident proton energy of 150 MeV for (a) outer most ($0d_{3/2}$ and $1s_{1/2}$) orbits and (b) inner ($0p_{3/2}$) orbit, as a function of the recoil momentum of the residue. The dark- and light-shaded bands correspond to the results with and without 3NF effects, respectively, and the width of each band represents the theoretical uncertainties coming from the cutoff dependence of the chiral interactions. The theoretical results include spectroscopic factors which are deduced from the $(e, e'p)$ reaction analysis [1]. The experimental data are taken from Ref. [2].

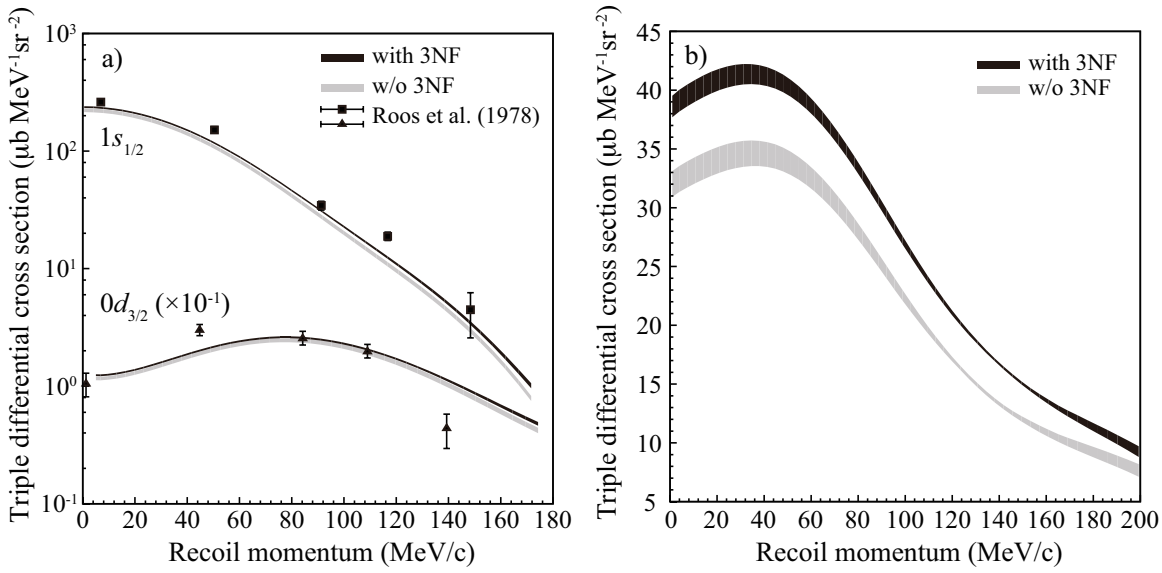

Figure 1: (Color online) Triple differential cross sections of ^{40}Ca(p,2p)^{39}K at the incident proton energy of 150 MeV for (a) outer most ($0d_{3/2}$ and $1s_{1/2}$) orbits and (b) inner ($0p_{3/2}$) orbit, as a function of the recoil momentum of the residue. The cross sections for $0d_{3/2}$ are multiplied by 10^{-1} for visibility.

The difference between the results with and without 3NF is small for $0d_{3/2}$ and for $1s_{1/2}$. In this case, since the protons bound in those outer-most orbits are knocked out mainly in the surface region of ^{40}Ca, the reaction process is hardly affected by the 3NF effects. However, for $0p_{3/2}$, the chiral 3NF effects significantly change the peak height of the triple differential cross section of (p,2p) reaction. The increase of the (p,2p) cross sections is due to the enhanced in-medium pp cross sections by the chiral 3NF effects. We thus concluded (p,2p) reaction is a new probe of 3NF effects in many-body reactions. See Ref. [3] for more detail.

References

[1] G. J. Kramer *et al.*, Phys. Lett. B **227**, 199 (1989).
[2] P. G. Roos *et al.*, Phys. Rev. Lett. **40**, 1439 (1978).
[3] K. Minomo, M. Kohno, K. Yoshida, and K. Ogata, Phys. Rev. C **96**, 024609 (2017).