Probing effect of tensor forces via ^{16}O(p,d) reaction

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The tensor forces which originate from the pion exchange play important roles in atomic nuclei as well as in neutron stars. It is well known that the tensor forces are essential to reproduce/explain the binding energies of the deuteron and alpha particles, and the non-zero quadrupole moment of the deuteron. In heavier nuclei, detailed analyses of experimental data on nuclear masses and the subsequent theoretical calculations have hinted at a possible importance of the tensor forces in changing the magic numbers and the orders of single-particle orbitals in light neutron-rich nuclei [1]. To search for a direct evidence of the effect of the tensor forces in heavier nuclei, we have performed ^{16}O(p,d) reaction at relatively high-momentum transfers. Dividing the cross sections populating each excited state by the one for the ground state, we found a marked enhancement of the ratio for the positive-parity state, indicating the existence of large components of high-momentum neutrons in the ground-state configurations of ^{16}O due possibly to the tensor forces [2].

The experiment was performed at the RCNP WS course using the Grand Raiden spectrometer [3]. Proton beams at 198, 295 and 392 MeV were directed onto an ice target [4]. The scattered deuteron particles were momentum analyzed and transported to the focal plane of the GR, where they were detected by two drift chambers and two 10-cm-thick plastic scintillators. The excitation energy spectra for the ^{16}O(p,d)^{15}O* reaction were reconstructed using the information of the proton beam energy, the scattering angle and the measured momenta of the deuterons. We found strong population of the positive-parity ($5/2^+$ and/or $1/2^+$) excited state(s) at high-momentum transfer; the cross sections were even greater than that of the ground ($1/2^-$) state. To examine the relative strength of the excited states, we divided the cross sections for the excited states by that of the ground state. Figure 1 shows the momentum-transfer (q) dependence of the ratios of the intensities of the $3/2^-$ (open symbols) and the positive-parity excited states (filled symbols) to that of the ground state. As opposed to the ratios for the positive-parity state(s) which increase almost by a factor of 30, the ratios for the $3/2^-$ state only triple from q=0.3 to 2.6 fm^{-1}, and is qualitatively understood by a CDCC-BA calculation. Similar theoretical calculation underestimate the ratios for the positive-parity states by almost an order of magnitude. The enhancement was qualitatively understood by considering squared TOSM-type momentum wave functions that take into account tensor forces. For details, see Ref. [2].

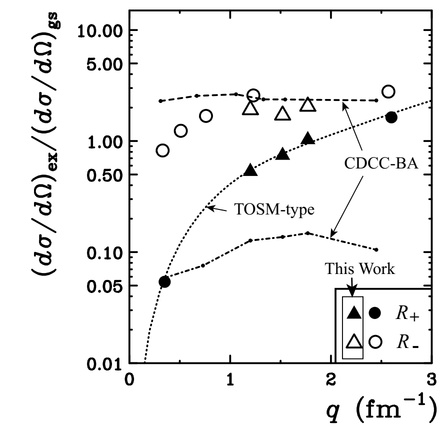

Figure 1: Ratios of cross sections of the $3/2^-$ (open symbols) and positive-parity ($5/2^+$ and/or $1/2^+$)(filled symbols) excited states to that of the ground state as functions of momentum transfer. See Ref. [2] for details.

References

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