Study of the tensor correlation in the neutron-rich sd-shell region with the charge- and parity-projected Hartree-Fock method*

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The tensor force plays important roles in nuclear structure. The study of nuclear matter and exact calculations in light nuclei revealed that the tensor force gives large attractive energy. Recently, Otsuka and his collaborators suggested that the shell structure changes with neutron number by the tensor force [1]. This result indicates that the tensor force may change the structure of neutron-rich nuclei from that of stable nuclei.

The important correlation induced by the tensor force is a 2-particle–2-hole ($2p2h$) correlation. The $2p2h$ correlation cannot be treated in a simple mean-field-type model. To treat the $2p2h$-type tensor correlation in a mean-field-type model, we introduce a single-particle state with parity and charge mixing considering the pseudoscalar and isovector characters of the pion, which mediates the tensor force. Because the total wave function consisting of the single-particle states with parity and charge mixing does not have a good parity and a definite charge number, we perform the parity and charge projection. By taking a variation of the projected wave function we obtain the Hartree-Fock-like equation. We call the equation the charge- and parity-projected Hartree-Fock (CPPHF) equation.

The CPPHF method was applied to sub-closed-shell oxygen isotopes [2]. In the oxygen isotopes the correlation energy from the tensor force is the same order as that from the LS force. The tensor correlation energy per particle decreases as a neutron number increases. This tendency occurs because excess neutrons around ^{16}O do not contribute to the tensor correlation. The tensor correlation energy does not disappear in LS closed nuclei, while the correlation energy from the LS force becomes negligible small. These properties may affect the structure change in a neutron-rich region.

We also study a 1-particle or 1-hole state. We found that the tensor force reduces the ls-splitting for the proton $0d$-orbits by few MeV in neutron-rich ^{23}F [3]. This effect comes from the interaction between excess neutrons and a proton around ^{16}O through the tensor force. Our calculation shows that the tensor force is important to reproduce the ls-splitting for $\nu p_{3/2}^{-1}$ and $\nu p_{1/2}^{-1}$ in ^{15}O and that for $\pi d_{5/2}$ and $\pi d_{3/2}$ in ^{23}F, which was recently determined experimentally [4], simultaneously, while the $2p2h$ correlation of the tensor force does not affect the ls-splitting largely.

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