Properties of the tensor correlation in He isotopes

T. Myo[1], S. Sugimoto[2], K. Katō[3], H. Toki[1] and K. Ikeda[2]
[1] *Research Center for Nuclear Physics (RCNP), Osaka University, Ibaraki, Osaka 567-0047, Japan*
[2] *Department of Physics, Graduate School of Science, Kyoto University, Kyoto 606-8502, Japan*
[2] *Division of Physics, Graduate School of Science, Hokkaido University, Sapporo 060-0810, Japan*
[3] *The Institute of Physical and Chemical Research (RIKEN), Wako, Saitama 351-0198, Japan.*

The tensor force is an essential component in nuclear force and plays an important role in the nuclear structure. In ^{4}He, the exact calculations show that the contribution of the tensor force in the energy is comparable to the central one.

It is an important problem to understand the effect of the tensor force on the nuclear structure in a physically transparent manner by explicitly describing the tensor correlation in the model space[1, 2, 3, 4, 5, 6] In this study, we investigate the roles of tensor force in ^{4}He and ^{5}He and start with the extended shell model approach for ^{4}He, which is considered to optimize the tensor correlation of this nuclei. For ^{5}He, we employ the "Tensor-optimized ^{4}He cluster"$+n$ model, and see the effect of the internal degrees of freedom of the tensor correlation on the structures of ^{5}He.

We examine what kind of correlation tensor force (tensor correlation) produces. The tensor force tends to change the parity of the nucleon single particle orbit due to the $(\boldsymbol{\sigma}\cdot\boldsymbol{r})$ operator. This is originated from the pion (pseudoscalar meson) because the tensor force mostly comes from the one-pion-exchange potential. Then, the $0s$ and $0p$ orbits is considered to be coupled by the tensor force in ^{4}He, and we describe ^{4}He as $(0s)^4+(0s)^2(0p)^2+\cdots$. Based on this idea, we extend the model space of ^{4}He up to h-shell within the $2p$-$2h$ excitation. This model converges the solutions, such as the contribution of the tensor force and D-state probability. For effective NN force, we use Akaishi force[4, 5, 6] constructed from the G-matrix theory using AV8' force, and consists of the central, tensor, and LS parts. We show the results of ^{4}He in Table 1. The large contribution of the tensor force is obtained and the probability (P) of the $(0s_{1/2})^2(0p_{1/2})^2$ component is large via 0^- coupling of the $0s_{1/2}$-$0p_{1/2}$ orbits. This reflects the pion nature.

Next we analyze the resonances of ^{5}He by solving the coupled channel problem of ^{4}He$+n$. Due to the large mixing of $0p_{1/2}$ component in ^{4}He, the Pauli blocking mainly occurs in the $1/2^-$ state in ^{5}He and 30% of the observed splitting energy of $1/2^-$–$3/2^-$ arises, which is consistent with old studies[8]. We furthermore investigate the effects of the tensor correlation on the d-wave properties of ^{4}He$+n$ system. The overall reproduction can be seen in the phase shifts, shown in Fig. 1.

Table 1: Results of ^{4}He.

Eenergy [MeV]	-27.6
$\langle V_{\rm tensor}\rangle$ [MeV]	-53.2
$P[(0s_{1/2})^4]$ [%]	85.66
$P[(0s_{1/2})^2(0p_{1/2})^2_{JT=10}]$	4.1
$P[(0s_{1/2})^2(1s_{1/2})(0d_{3/2})_{10}]$	2.3
$P[(0s_{1/2})^2(0p_{3/2})(0f_{5/2})_{10}]$	2.0
P[D]	9.1

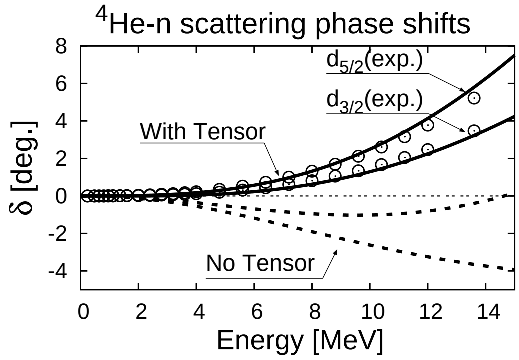

Figure 1: Results of ^{4}He-n scattering phase shifts.

References

[1] H. Toki, S. Sugimoto, K. Ikeda, Prog. Theor. Phys.**108**,903(2002).
[2] Y. Ogawa, H. Toki, S. Tamenaga, H. Shen, A. Hosaka, S. Sugimoto and K. Ikeda, Prog. Theor. Phys.**111**,75(2004).
[3] S. Sugimoto, K. Ikeda, H. Toki, Nucl. Phys.**A740**,77(2004).
[4] Y. Akaishi, Nucl. Phys. **A738**,80(2004).
[5] K. Ikeda, S. Sugimoto, and H. Toki, Nucl. Phys.**A738**73(2004).
[6] T. Myo, K. Katō and K. Ikeda, Prog. Theor. Phys.**113**,763(2005).
[7] S. Nagata *et al.*, Prog. Theor. Phys.**22**,87(1959).
[8] T. Terasawa, Prog. Theor. Phys.**22**,150(1959); *ibid.* **23**,87(1960). A. Arima and T. Terasawa, Prog. Theor. Phys.**23**,115(1960).