Tensor correlation in He isotopes

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The tensor force is an important component in nuclear force and plays an important role in the nuclear structure, such as the saturation property and clustering phenomena. In ^{4}He, the contribution of the tensor force in the energy is comparable to the central one.

In this study, we investigate the role of tensor force in the He isotopes including a halo nucleus ^{6}He[1]. In most calculations of halo nuclei, an inert core+$n(+n)$ model is often used, such as the $(0s)^4$ description of ^{4}He core in ^{6}He. But, this model cannot incorporate the tensor force and the phsical aspects of tensor correlations have not been realized yet in He isotopes.

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 operator of $(\boldsymbol{\sigma}\cdot\boldsymbol{r})$. This is originated from the pion (pseudoscalar meson) because tensor force mostly comes from the one-pion-exchange potential[2, 3, 4]. Then, in ^{4}He, we consider that the $0s$ and $0p$ orbits can be coupled by tensor force and the description of ^{4}He is extended to $(0s)^4+(0s)^2(0p)^2$. We first show the effect of tensor correlation in ^{4}He, where we use the harmonic oscillator wave function and take the length parameter of the $0s$ and $0p$ orbits ($b(0p)$ and $b(0p)$) freely and determine them variationally. For effective NN force, we use Akaishi force[5, 6] constructed from the G-matrix theory using AV8' force, and consists of the central, tensor, and LS parts. We furthermore tune the central part to fit the binding energy (28.3 MeV) and matter radius (1.48 fm) of ^{4}He. In Table 1, we show the results of ^{4}He, in which the $0p$ orbit is narrow to represent the higher shell component from the tensor force, and the probability (P) of the $(0s_{1/2})^2(0p_{1/2})^2$ component is large via 0^- coupling of the $0s_{1/2}$ and $0p_{1/2}$ orbits. This reflects the pion nature[1, 4, 5].

Next we analyze the p-wave resonances of ^{5}He by solving the coupled channel problem of ^{4}He+n. Due to the large mixing of $0p_{1/2}$ component from the tensor correlation in ^{4}He, the Pauli blocking mainly occurs in the $1/2^-$ state in ^{5}He and the splitting of $1/2^-$–$3/2^-$ can arise. To show this, a single Gaussian potential is used for ^{4}He-n without LS part. The results of phase shifts are shown in Fig.1 in which the tensor correlation produces the half amount of the observed splitting, which is consistent with other studies[7, 8].

We also show the preliminary spectrum of ^{6}He with three-body calculation in Fig. 1. It is found that the 0_2^+ states is strongly affected by the tensor correlation in which two valence neutrons occupy the $0p_{1/2}$ orbit and suppress the tensor correlation in ^{4}He core due to the Pauli-blocking.

Table 1: Results of ^{4}He.

$b(0s)$ [fm]	1.39
$b(0p)$ [fm]	0.79
$\langle V_{\rm tensor}\rangle$ [MeV]	-29.9
$P[(0s_{1/2})^2(0p_{1/2})^2]$ [%]	9.0
$P[(0s_{1/2})^2(0p_{3/2})^2]$	3.4
$P[(0s_{1/2})^2(0p_{3/2})(0p_{1/2})]$	0.1

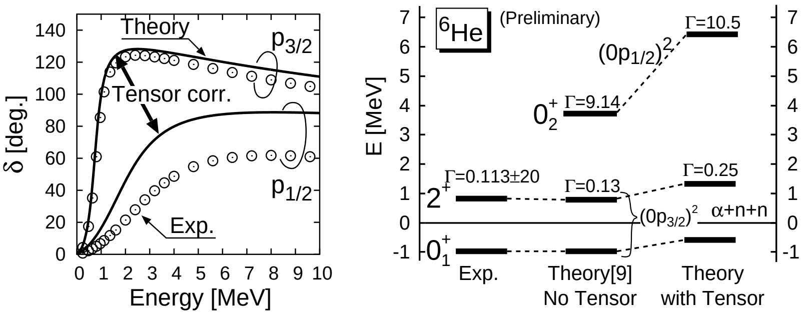

Figure 1: Results of ^{5}He and ^{6}He.

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