Systematic study of ^{9,10,11}Li with the tensor and pairing correlations

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So far, many experiments have been performed on ^{11}Li and the surrounding nuclei in order to understand the exotic structures of these nuclei. Experimentally, the halo neutrons in ^{11}Li are known to have almost equal amount of the s-wave component with respect to that of p-wave[1]. The challenge from the theoretical side is the mechanism of a large s-wave component for the halo neutrons, namely the disappearance of the $N = 8$ magic number.

In the previous study[3], we have considered newly the tensor correlation in ^{11}Li based on the extended three-body model, where the tensor correlation in the ^{9}Li core is described fully in the tensor-optimized shell model. It was found that the tensor and pairing correlations in ^{9}Li inside ^{11}Li are Pauli-blocked by additional two neutrons, which makes the $(1s)^2$ and $(0p)^2$ configurations close to each other to mix about equal amount of two configurations. As a result, we naturally explained the breaking of magicity and the halo formation for ^{11}Li with 47% of the $(1s)^2$ component. We also reproduced the Coulomb breakup strength[2] of ^{11}Li.

In this report, following the previous study[3], we demonstrate the reliability of our framework by performing a detailed systematic analysis of the structures of ^{9,10,11}Li[4]. For the dipole strength of ^{11}Li into ^{9}Li+n+n state, we observe the low energy peak shown in Fig. 1. We investigate the effect of the final state interactions between the ^{9}Li+n+n system, by which either the core-n (V_{cn}) or nn (V_{nn}) interaction is cut off, respectively, or both of them are cut off, namely, the plane wave treatment, shown in Fig. 1. The results show that the plane wave gives the small strength, which indicates the importance of the final state correlations. Among the final state correlations, the core-n and nn interactions give comparable contributions. This means that both two correlations are important to explain the three-body breakup mechanism of ^{11}Li.

We also show the Q moments of the ^{9}Li and ^{11}Li in Table 1. Only the absolute value is reported for ^{11}Li in the experiments[5]. The present model describes well the observations. It is found that the difference between the values of ^{9}Li and ^{11}Li is small. This trend is different from the the charge radius case, in which the enhancement in ^{11}Li is caused by the recoil effect coming from the large ^{9}Li-2n distance as 5.69 fm[3]. We here discuss the recoil effect in the Q moment of ^{11}Li by expanding its operator into the core part, the ^{9}Li-2n relative motion part. In our wave function of ^{11}Li, 2n almost form the 0^+ state with around 99%. Hence, the Q moment from the relative motion part almost vanishes because of the rank condition. This means that the recoil effect is negligible and the Q moment of ^{11}Li comes from the ^{9}Li core part. It is desired that further experimental data are obtained for the Q moment of ^{11}Li.

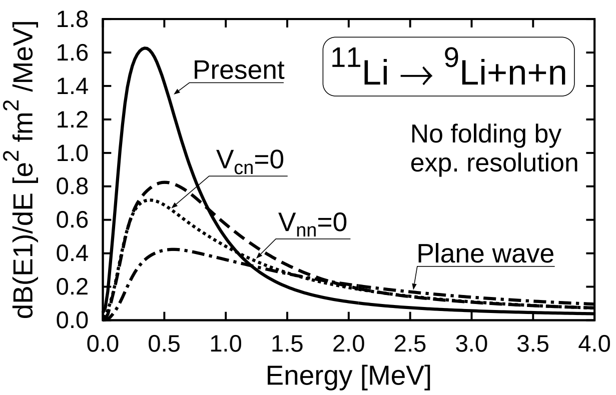

Figure 1: Effect of the final state interactions on the $E1$ transition strength of ^{11}Li into the ^{9}Li+n+n system.

Table 1: Q moments of ^{9}Li and ^{11}Li in units of e fm^2.

	^{9}Li	^{11}Li
Present	-2.65	-2.80
Experiment[5]	-2.74 ± 0.10	3.12 ± 0.45 ($\|Q\|$)

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