

High-momentum components in the ${}^4\text{He}$ nucleus caused by inter-nucleon correlations

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High-momentum components of nuclei are essential for understanding the underlying inter-nucleon correlations in nuclei. In this report, we provide a fine-grained analysis for the different types of inter-nucleon correlations in the ${}^4\text{He}$ nucleus and investigated their contributions to the high-momentum components.

We obtain the *ab initio* wave function of ${}^4\text{He}$ nucleus [1] by adopting the the AV8' bare NN interaction and the tensor-optimized high-momentum antisymmetrized molecular dynamics (TO-HMAMD) model that is formulated in our previous works. The nucleon momentum distributions is then calculated from this TO-HMAMD wave function using a new technique developed in this work. The numerical results predict the high-momentum components and the distribution calculated from the TO-HMAMD wave function reproduces the experimental data.

We further clarify the physical origins of the high-momentum component in ${}^4\text{He}$ nucleus via the decomposition of the TO-HMAMD wave function into the orthogonal components consisting of AMD, central, tensor and many-body channels, as shown in the left panel of Fig. 1. The contribution from each channel to the total momentum distribution were calculated individually. From these results, we observe the tensor dominance around $k \approx 2 \text{ fm}^{-1}$ and the short-range dominance around $k \approx 4 \text{ fm}^{-1}$.

For the manifestation of tensor correlation in ${}^4\text{He}$ nucleus, the nucleon momentum distributions are calculated by using both the AV4' and the AV8' interactions, and they are compared with the experimental data, as shown in the right panel of Fig. 1. It is found that the tensor correlation is essential for the reproduction of the smooth momentum distribution around $k \approx 2 \text{ fm}^{-1}$ in the experimental data, which is a clear indication for the existence of tensor correlation in the ${}^4\text{He}$ nucleus. Using the theoretical models formulated in this and our previous works, we expect to describe the high-momentum components for heavier nuclei in future.

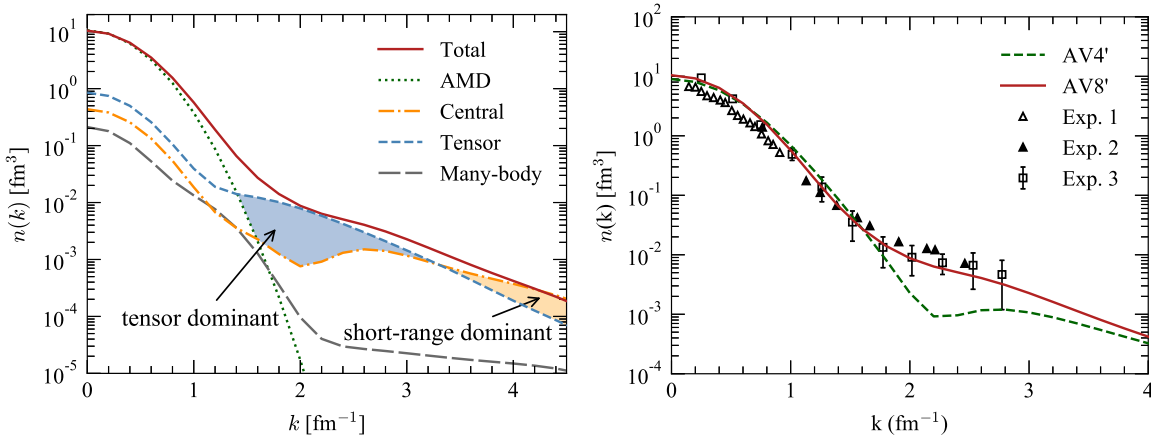


Figure 1: (*left*) Decomposition of the high momentum component of the ${}^4\text{He}$ nucleus. “Total” denotes the nucleon momentum distribution of the entire TO-HMAMD wave function. “AMD”, “Central”, and “Tensor” denote nucleon momentum distributions contributed by corresponding component. (*right*) Nucleon momentum distribution of ${}^4\text{He}$ calculated with the AV4' and the AV8' interactions in the TO-HMAMD framework. The experimental data are adopted from Ref. [2]

References

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