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Hypernuclear production spectroscopy with an extended shell model

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The $(e, e'K^+)$ reaction experiments with several nuclear targets performed recently at the Jefferson Lab have provided high-resolution spectroscopic data. They are very fruitful in disclosing hypernuclear structure details and also in understanding hyperon-nucleon fundamental interaction properties.

Among others, the ^{10}B $(e, e'K^+)$ $^{10}_{\Lambda}$Be reaction data are quite interesting, because they have shown extra subpeaks which seem difficult to be explained within the conventional model with the p-shell nuclear natural-parity configurations. In order to describe this novel hypernuclear structure, we have extended the model space by introducing the new configurations which include unnatural-parity nuclear core-excited states. In the extended model for each hypernuclear state of $J^{\pm}$, we take four types of configurations, $[J^+_{c(i)} \otimes s^{\Lambda}]_{J^+}$, $[J^+_{c(i)} \otimes p^{\Lambda}]_{J^-}$, $[J^-_{c(i)} \otimes s^{\Lambda}]_{J^-}$, and $[J^-_{c(i)} \otimes p^{\Lambda}]_{J^+}$, where $J^{\pm}_{c(i)}$ denotes all the possible spin-parity states of core-nucleus, and s^{Λ} and p^{Λ} denote the single-particle states of Λ hyperon. We take into account all the states of core-nuclei in the $0\hbar\omega$ and $1\hbar\omega$ space, which are labeled with i. It is interesting to point out that the nuclear core eigenstates with different parities are mixed by the Λ participation. For the $^{10}_{\Lambda}$Be hypernucleus, natural- and unnatural-parity nuclear-core configurations, $[J^+_{c(i)} \otimes p^{\Lambda}]_{J^-}$ and $[J^-_{c(i)} \otimes s^{\Lambda}]_{J^-}$, can be mixed easily by the ΛN interaction at appropriate excitation energy. We emphasize that, for the first time, this configuration mixing successfully explains the extra subpeaks in the ^{10}B $(e, e'K^+)$ reaction experiments.

For adjacent hypernuclei with $A = 9$-12, we will show the energy levels and the DWIA cross-sections of (K^-, π^-), (π^+, K^+), and (γ, K^+) reactions that are calculated within the extended model space. We focus on the interesting behavior of Λ p-state. In $^{9}_{\Lambda}$Be, it is well known that the Λ p-state splits into two orbital states, p-perpendicular and p-parallel states, which is due to the strong coupling with nuclear core deformation having the α-α structure. We will discuss the theoretical spectrum of ^{10}B (K^-, π^-) $^{10}_{\Lambda}$B and ^{11}B (K^-, π^-) $^{11}_{\Lambda}$B reactions, and will show the two peaks corresponding to the p-perpendicular and p-parallel states. The extended model study will be useful for new projects of $(K^-, \pi^-\gamma)$ and $(\pi^+, K^+\gamma)$ reaction experiments with high-intensity and high-resolusion that are being planned at J-PARC.

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