Structure of few-body light Λ hypernuclei

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In 2013, a neutron rich Λ hypernucleus, ${}^{7}_{\Lambda}$He was observed via the $(e, e'K^+)$ reaction and an observed Λ separation energy of $B_\Lambda = 5.68 \pm 0.03 \pm 0.25$ MeV was reported [1]. This hypernucleus is interesting from the following three points: (1)We can get information about charge-symmetry-breaking (CSB) components in the ΛN interaction. It is considered that the most reliable evidence for CSB appears in the Λ-separation energies (B_Λ) of the $A = 4$ hypernuclei with $T = 1/2$ (${}^{4}_{\Lambda}$H and ${}^{4}_{\Lambda}$He). Then, the CSB effects are attributed to the separation-energy difference $\Delta_{\rm CSB} = B_\Lambda({}^{4}_{\Lambda}\mathrm{He}) - B_\Lambda({}^{4}_{\Lambda}\mathrm{H})$, the experimental values of which are 0.35 ± 0.06 MeV and 0.24 ± 0.06 MeV for the ground (0^+) and excited (1^+) states, respectively. It is also likely that CSB contribution affects to the binding energy of ${}^{7}_{\Lambda}$He and the experimental research at JLab on the ${}^{7}_{\Lambda}$He was motivated by this question. (2) Using this gluelike role of Λ particle, we have another question ' 'Is there a possibility to have other new hypernuclear states in ${}^{7}_{\Lambda}$He?' To answer this question, it is necessary to look at the energy spectra of ^{6}He core nucleus before studying ${}^{7}_{\Lambda}$He. The observed data of ^{6}He [2] reported 0^+_1 round state as a bound state and the 2^+_1 resonant state with $E_{\rm x} = 1.797$ MeV, $\Gamma = 0.113$ MeV. To search the second 2^+ state, some experiments were performed. For example, the charge-exchange reaction, ^{6}Li(t,^{3} He)^{6}He, was studied to explore the excited states above the first 2+ state [3]. However, clear evidence of the second 2+ state was not obtained. In 2012, in Ref. [4], the transfer reaction experiment $p({}^{8}\mathrm{He}, t){}^{6}\mathrm{He}$ shows an indication of the second 2^+ state of ^{6}He as a resonant state at $E_{\rm x} = 2.6 \pm 0.3$ ($\Gamma = 1.6 \pm 0.4$) MeV. When a Λ particle is added to such a resonant state, due to a gluelike role of Λ particle, it is likely to result in narrower resonant states of $3/2^+_2$ and $5/2^+_2$ of ${}^{7}_{\Lambda}$He. The prediction of energies of second $3/2^+$ and $5/2^+$ states and decay widths would encourage further experimental investigation of ${}^{7}_{\Lambda}$He at JLab. (3) This observation stimulated us to study neutron-rich Λ hypernuclei because in light nuclei near the neutron drip line, interesting phenomena concerning neutron halos have been observed. When a Λ particle is added to such nuclei, it is expected that the resultant hypernuclei will become more stable against neutron decays due to the attraction of ΛN interaction and the fact that there is no Pauli exclusion effect between nucleons and a Λ particle. This phenomenon is one of the 'gluelike' roles of Λ particle.

In the Conference, I will report the above three issues within the framework of $\alpha + \Lambda + n + n$ four-body problem.

References

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