Contribution ID: **119** Type: **not specified**

Prospect of hadronic-molecule with strangeness

Thursday 29 August 2024 09:15 (30 minutes)

Recently, we conducted a kaonic nuclear-bound state search experiment using a K^- beam (1 GeV/c) bombarding a ^{3}He target. We succeeded in observing a kaonic nuclear quasi-bound state, "K^-pp", via a nucleon knockout reaction, $K^-N \to \overline{K}n'$, followed by the decay $\overline{K}NN \to \Lambda p(2N_{\overline{K}A})$ in the two-nucleon $\overline{K}$ absorption process, resulting in the final state $\Lambda p + n'$. The result shows that the "K^-pp" binding energy is about 40 MeV below the binding threshold, with a decay width of about 100 MeV. From the Λp decay, the isospin of the system is determined to be $I_{\overline{K}NN} = 1/2$. The momentum transfer distribution of the Λp system is very broad, implying that the size of the "K^-pp" system might be very compact [1, 2].

We extended our study on the kaonic nuclear-bound state in two ways: A) by studying the mesonic decay process of the $\overline{K}NN$ via one-nucleon $\overline{K}$ absorption ($1N_{\overline{K}A} : \overline{K}N \to \pi Y$), and B) by searching for the $\overline{K}NNN$ bound state through the Λd invariant mass study of the $\Lambda d + n'$ final state with a k^- beam (1 GeV/c) bombarding a ^{4}He target. The aim of A) is to understand why the decay width of "K^-pp" is about twice as broad as that of $\Lambda(1405)$ (≈ 50 MeV), which is assumed to be a molecule-like hadronic cluster composed of a $\overline{K}$ meson and a nucleon, i.e., $\Lambda(1405) \equiv \overline{K}N$, as introduced by R. H. Dalitz et. al. [3]. The result shows that the $\overline{K}NN \to \pi YN$ decay is dominant ($1N_{\overline{K}A} \gg 2N_{\overline{K}A}$) and that the $\pi\Sigma N$ to $\pi\Lambda N$ ratio is about 1:1, indicating that the $I_{\overline{K}N} = 1$ absorption channel is approximately equal to the $I_{\overline{K}N} = 0$ channel. The result also suggests that there is a hint of the "$\overline{K}^0nn$" bound state, a charge mirror state of "K^-pp", existing in the $\pi^-\Lambda p$ invariant mass spectrum of the $\pi^-\Lambda p + p'$ final state.

In the Λd invariant mass study B), the two dimensional preliminary spectrum of the Λd invariant mass and the momentum transfer to Λd ($m_{\Lambda d}, q_{\Lambda d}$) shows an almost identical distribution to ($m_{\Lambda p}, q_{\Lambda p}$), indicating the presence of $\overline{K}NNN$, decaying to Λd. If this is another kaonic nuclear-bound state, then the isospin, spin parity is fixed to be $I(J^P) = 0(1/2^-)$.

In this talk, we'll describe these two new results on kaonic nuclear-bound states and discuss the prospects of studying the molecule-like hadronic cluster with strangeness.

References

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[2] T. Yamaga et al., Phys. Rev. C 102, 044002 (2020)
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