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Experimental study of K̄NN and future experiments for kaonic nuclei

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The existence of a quasi-bound state of antikaon and nucleus, kaonic nucleus, has been discussed ever since the $\bar{K}N$ interaction in $I = 0$ channel was confirmed to be strong attractive.
The $\bar{K}NN$ quasi-bound state is the lightest kaonic nucleus which is considered to be $I = 1/2$ and $J^{\pi} = 0^{-}$. To search for the $I_z = +1/2$ $\bar{K}NN$ state we conducted the J-PARC E15 experiment using the in-flight K^--beam at J-PARC. Because the K^--beam momentum of 1 GeV$/c$ used in the experiment maximizes the elementary cross section of nucleon knocked-out reactions, $(K^-,\ N)$, the $I_z = +1/2$ $\bar{K}NN$ state is expected to be produced by sequential reaction of the primary $(K^-,\ n)$ reaction followed by an absorption process of intermediate $\bar{K}$ to residual nucleons. Production of the $I_z = +1/2$ $\bar{K}NN$ state was examined by an exclusive analysis for the simplest non-mesonic reaction, $K^-\ {}^3\mathrm{He} \to \Lambda pn$, in which Λp pair is expected to be decay products of the $\bar{K}NN$.In the Λp invariant-mass spectrum, we observed a distinct peak at the energy region below the $\bar{K}NN$ mass threshold. Because its peak position does not depend on the momentum transfer to the Λp system, the peak is produced by a resonance. Although the spectral decomposition was performed using the simple Breite-Wigner formula, whole distribution is reproduced well. The evaluated mass position and decay width are consistent with theoretical predictions, thus we concluded that the observed peak is a signal of the $I_z = +1/2$ $\bar{K}NN$ state.

As future prospects, there are two approaches to establish the kaonic nuclei more robustly. One is to search for heavier kaonic nuclei, and another is to study the observed $\bar{K}NN$ state more precisely. Thus, we have planed to perform series of experiments to study of kaonic nuclei using in-fight K^- reactions at J-PARC.
As an analogy to $\bar{K}NN$ production with the $(K^-,\ n)$ reaction, heavier kaonic nuclei could be produced similarly by replacing ^{3}He-target with heavier targets. As the first step to search for heavier kaonic nuclei, $\bar{K}NNN$ state will be searched for with the ${}^4\mathrm{He}(K^-,\ n)$ reaction. For the $\bar{K}NN$ state, determination of spin-parity is the most important to confirm the observed state is a quantum state as well as to clarify its internal structure. J^{π} of the $\bar{K}NN$ can be determine from the spin-spin correlation of the Λp-pair from the $\bar{K}NN$ decay with a model independent manner.
As another measurement for the $\bar{K}NN$, we will measure the ${}^3\mathrm{He}(K^-,\ p)\Lambda n$ reaction to search for the $I_z = -1/2$ $\bar{K}NN$ state.
To perform these measurements, we will construct a new solenoid spectrometer system to have neutron detection capability and a proton polarimeter system.

I would like to present the summary of J-PARC˜E15 experiment and an overview of our future plan.

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