Contribution ID: 93

Type: talk

## Search for the KNNN bound state in the Adn final states of the in-flight K<sup>^</sup>- reaction on helium-4

Monday 27 June 2022 18:10 (15 minutes)

In recent years, the possible existence of deeply-bound  $\bar{K}$  nuclear bound states has been widely discussed as a consequence of the strongly attractive  $\bar{K}N$  interaction in I = 0 channels. Very recently, J-PARC E15 experiment reported an observation of the simplest kaonic nuclei,  $\bar{K}NN$ , in the  $\Lambda p$  invariant-spectrum of the in-flight  $K^-$  reaction on helium-3 [PLB789(2019)620, PRC102(2020)044002]. If the observed structure is truly the kaonic nuclear state, we can expect other kaonic nuclei can be produced in the same  $K^-$  induced reaction. Observation of other kaonic nuclei would provide a further support for the existence of such exotic states. Furthermore, mass-number dependence of kaonic nuclear systems would be of great importance to study interplay between the  $\bar{K}N$  attraction and the NN repulsion at short distances.

Here, we focus on the second simplest system,  $\bar{K}NNN$  with I = 0. This state could be populated by simply replacing the helium-3 target in J-PARC E15 with helium-4. Although the branching ratio is not known, one of the expected decay modes is  $\Lambda d$ , whose final particles are charged ones only. By detecting the  $\Lambda d$  pair and by identifying neutron via the missing-mass method, we can exclusively study the  $\Lambda dn$  final states in the same manner of  $\Lambda pn$  in E15.

We already had a chance to collect  $K^-$ -induced data on helium-4 as a feasibility test of a lifetime measurement of light hypernuclei (J-PARC T77). Approximately  $6 \times 10^9 K^-$  particles at 1 GeV/*c* are delivered to the helium-4 target in ~3-day beam time in June 2020. This number corresponds to ~1/7 of that in E15. The decay particles are detected with the same cylindrical detector system as E15. In a preliminary analysis, we successfully reconstructed several hundreds of  $\Lambda dn$  events.

In this contribution, we would like to present the latest results of the  $\Lambda dn$  analysis described above, and discuss future prospects towards more comprehensive investigation of the  $\bar{K}NNN$  system.

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Session Classification: 1; Mon-IV