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Recent progress and prospects of kaonic nuclear bound states at J-PARC

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In recent years, the possibility that an anti-kaon ($\bar{K}$) could become a constituent particle of a nucleus has been widely discussed based on the strongly attractive $\bar{K}N$ interaction in the $I = 0$ channel. After many experimental efforts over the decades, we reported an observation of the simplest kaonic nuclear-bound state, “ K^-pp ”. We observed the state in the Λp invariant-spectrum of the in-flight K^- reaction on helium-3 in the J-PARC E15 experiment [PLB789(2019)620, PRC102(2020)044002]. This K^- -induced reaction is indeed a good way to excite the sub-threshold $\bar{K}$, so we will proceed with further study of various kaonic nuclei at J-PARC.

One direction is to investigate heavier systems, such as a three-nucleon system “ K^-ppn ”. This state could be populated by simply replacing the helium-3 target with helium-4, but a neutron would be emitted as a decay particle. Another direction is to investigate the observed “ K^-pp ” state in more detail. We will search for the iso-spin partner state “ $\bar{K}^0nn$ ”, and the spin-parity of the “ K^-pp ” will be studied by means of a spin-spin correlation measurement between decay Λ and proton. These studies, together with theoretical discussions, will further establish the existence of the kaonic nuclear-bound states and reveal their nature.

We are now constructing a new solenoid spectrometer having almost 4π (93%) solid angle and much better neutron detection capability. The construction is to be completed in two years, and the first data-taking with a helium-4 target will start in 2027 as the J-PARC E80 experiment. Even before that, we recently obtained some datasets with a helium-4 target and additional helium-3 data with a partially upgraded setup of the E15.

In this contribution, we present the latest results from the existing E15 spectrometer. We also present the construction status of the new spectrometer and discuss future prospects with it.

Primary author: HASHIMOTO, Tadashi (RIKEN)

Presenter: HASHIMOTO, Tadashi (RIKEN)

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