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Prospect for the gamma-ray spectroscopy experiment of ${}^{4}_{\Lambda}\mathrm{H}$ with Hyperball system (J-PARC E63)

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Content

To study a large charge symmetry breaking (CSB) effect observed in the Λ binding energy of four-body hypernuclei, ${}^{4}_{\Lambda}\mathrm{H}$ and ${}^{4}_{\Lambda}\mathrm{He}$, we will perform a precise measurement of ${}^{4}_{\Lambda}\mathrm{H}(1^{+} \rightarrow 0^{+})$ gamma-ray transition by using the high-resolution Ge detector array (Hyperball system) at J-PARC (E63 experiment).

In 2015, the gamma-ray from ${}^{4}_{\Lambda}\mathrm{He}(1^{+} \rightarrow 0^{+})$ transition was measured by our group by using a high-resolution Ge detector array at J-PARC and the presence of a large CSB effect was confirmed [1]. In contrast to ${}^{4}_{\Lambda}\mathrm{He}$, gamma-ray data from ${}^{4}_{\Lambda}\mathrm{H}$ were reported from older three experiments [2-4] but these are less reliable due to low statistics and worse resolution caused by using NaI detectors, and reported energy values are slightly different from each other. Therefore, we plan to carry out the J-PARC E63 to determine the energy reliably and precisely with Ge detectors.

The E63 experiment will be performed at the J-PARC K1.8 beam line. The ${}^{4}_{\Lambda}\mathrm{H}$ is produced as a hyperfragment from an unbound excited state of ${}^{7}_{\Lambda}\mathrm{Li}$ (${}^{7}_{\Lambda}\mathrm{Li}^{*}$) which is produced by the (K^{-}, π^{-}) reaction with a ${}^{7}\mathrm{Li}$ target via missing mass measurement using the K1.8 beam line spectrometer and the S-2S spectrometer. To produce ${}^{7}_{\Lambda}\mathrm{Li}^{*}$, a low momentum K^{-} beam (~0.9 GeV/c) will be used, because the small hyperon recoil momentum in the 0.9 GeV/c (K^{-}, π^{-}) reaction allows for dominant population of ΔL =0 (substitutional) states as well as suppression of Doppler broadening of gamma-rays. To confirm the feasibility of the E63 experiment, a 0.9 GeV/c K^{-} beam test was carried out for the first time at the K1.8 beam line in April 2024. The K^{-} beam intensity was found to be sufficient for the gamma-ray measurement of ${}^{4}_{\Lambda}\mathrm{H}$. Based on this result, the experiment is scheduled to be run in November 2025. In addition, test data for the (K^{-}, π^{-}) reaction with a $(\mathrm{CH})_{\mathrm{n}}$ target was also obtained using a 0.9 GeV/c K^{-} beam, and missing mass spectra for ${}^{12}_{\Lambda}\mathrm{C}$ and Σ^{+} were obtained to check the spectrometer performance.

In this paper, the motivation and preparation status of E63 experiment will be reported, and the results of the K^{-} beam intensity measurement and the analysis of the (K^{-}, π^{-}) reaction data with the $(\mathrm{CH})_{\mathrm{n}}$ target will be presented. In addition, for future experiments of hypernuclear gamma-ray spectroscopy which are planned with (K^{-}, π^{-}) reactions with 0.9-1.8 GeV/c K^{-} beam, the measured cross section of ${}^{12}_{\Lambda}\mathrm{C}$ at 0.9 GeV/c will be discussed together with the cross sections at 1.5 and 1.8 GeV/c which were obtained so far.

Reference

[1] T. O. Yamamoto et al., Phys. Rev. Lett. 115, 222501 (2015).
[2] M. Bedjidian et al., Phys. Lett. B 62, 467 (1976).
[3] M. Bedjidian et al., Phys. Lett. B 83 252 (1979).
[4] A. Kawachi, Docter thesis, University of Tokyo, 1997.

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