Prospects of missing-mass spectroscopy of Λ hypernuclei via the (π^+, K^+) reaction using a high resolution spectrometer S-2S

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Content

Hypernuclei serve as essential instruments for examining hyperon-nucleon (YN) and hyperon-hyperon (YY) interactions. Previous study has been shown that charge symmetry breaking (CSB) is observed in A=4 systems containing Λ particles. To understand the CSB problem, a systematic investigation of other Λ hypernuclei, such as p-shell systems containing $^{12}_{\Lambda}$C and $^{10}_{\Lambda}$B, is required. To study CSB in p-shell hypernuclei, it is important to compare isomultiplet hypernuclear structures produced by non-charge exchange reactions such as (π^+, K^+) reaction and single-charge exchange reactions such as (e, e' K^+) reaction. Recent (e, e' K^+) reaction spectroscopy experiment at the Jefferson Laboratory (JLab), has been achieved to 0.78 MeV (FWHM) missing mass resolution in $^{10}_{\Lambda}$Be [1], whereas (π^+, K^+) reaction spectroscopy experiment at KEK-PS is approximately 2 MeV (FWHM) in $^{10}_{\Lambda}$B [2], which is not accurate enough to validate theoretical models concerning ΛN CSB effects. In addition, it has been pointed out that there might been a 0.5—0.6 MeV shift in $^{12}_{\Lambda}$C binding energy measured via the (π^+, K^+) reaction at KEK-PS. Since the binding energy of $^{12}_{\Lambda}$C was used as the calibration reference for the missing mass spectra of other hypernuclei produced via the (π^+, K^+) reaction, a high precision reexamination is essential.

Consequently, we plan to perform high-precision and high-accuracy Λ hypernuclear spectroscopy via the (π^+, K^+) reaction at J-PARC, on targets of p-shell nuclei, specifically ^{7}Li, ^{10}B, and ^{12}C(J-PARC E94[3]). E94 will be conducted using the S-2S spectrometer, a high-resolution magnetic spectrometer for scattered particle. In E94 condition, the binding energy resolution is estimated to be 0.7—1.4 MeV (FWHM) using the S-2S spectrometer. The first experiment with the new S-2S spectrometer, which was for Ξ hypernuclear spectroscopy, was completed in May 2025. Preliminary results from this initial experiment indicate that high-precision spectroscopy of Λ hypernuclei is feasible, although further analysis to enhance resolution is ongoing. In the E94 experiment, π^+ beam, reaching up to 5 M/spill (1 spill = 4.2 sec.), is planned for use.

In this presentation, I will talk an overview of E94, including the experimental conditions based on pilot data. Additionally, I will discuss the future prospects of Λ hypernuclear spectroscopy using S-2S following the E94 experiment.

Reference

[1] T. Gogami et al., PRC93, 034314 (2016).
[2] O. Hashimoto and H. Tamura, Prog. Part. Nucl. Phys. 57, 564-653 (2006).
[3] T. Gogami et al., Proposal to J-PARC, E94 (2022).

Field of Research: Production, structure and decay of hypernuclei / Future experiments and facilities
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