Progress of the hypernuclear decay pion spectroscopy program at MAMI-C

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for the A1 hypernuclear collaboration

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Investigations of Λ hypernuclei are important to understand the hyperon-nucleon interaction, structures of neutron stars, and unique behaviors of hypernuclei. The binding energy of Λ in the hypernuclei is one of the most fundamental and important information for Λ hypernuclei. Most of the absolute binding energies for the ground states in the light hypernuclei were measured by the emulsion experiments in 1970's [1-4]. The excitation energies have been measured by counter experiments: e.g. missing mass spectroscopy and gamma ray spectroscopy. From the results of these experiments and theoretical predictions, the understandings of the ΛN interaction have progressed. However, the energy levels of light hypernuclei such as A=4 iso-doublet hypernuclei have not yet fully understood: ${}^{4}_{\Lambda}$H and ${}^{4}_{\Lambda}$He [5-6]. A large charge symmetry breaking potential between Λ and nucleon (Λ-N CSB) was introduced to reproduce ground and excited states energies of ${}^{4}_{\Lambda}$H and ${}^{4}_{\Lambda}$He simultaneously [7]. However, the origin of large ΛN CSB potential has not been investigated well. More precise data for various hypernuclei are definitely necessary. Recently, a binding energy of ${}^{7}_{\Lambda}$He, which was the last missing piece of A=7 iso-triplet hypernuclei, was newly reported from the JLab E01-011 experiment [8]. An excited energy of $^{4}_{\Lambda}$He will be measured with an accuracy of a few keV in the J-PARC E13 [9]. Much more statistics for several kinds of Λ hypernuclei can be expected by overall scan technique in J-PARC E07 [10].

We designed cutting-edge experimental technique measuring the absolute binding energy of the ground state for the light hypernuclei with high accuracy: called "hypernuclear decay pion spectroscopy". In the hypernuclear decay pion spectroscopy, we measure the momentum of the two-body decayed pion from a hypernucleus stopped in the target. With this new technique we can obtain the binding energy with about 30 keV accuracy thanks to the small energy struggling effect in a very thin target (~20 mg/cm^2) and the high yield of the high intensity electron beam at Mainz Microtron C (MAMI-C). We have measured the momenta of the decayed pions with "Spek-A" and "Spek-C" which have the relative momentum resolution of 10^{-4} and the large solid angle of 28 msr. In addition, we tagged K^+ to suppress the non-strangeness background in spectrometer "Kaos".

We have performed the first feasibility experiment in 2011 and upgraded experiment in 2012. We have successfully identified the decayed pion from $^{4}_{\Lambda}$H and deduced its binding energy. We are planning to take much more data with lower background condition in 2014.

I will report the latest results of hypernuclear decay pion spectroscopy, and discuss about binding energy of Λ in $^{4}_{\Lambda}$H and its formation probability.

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