Spectroscopic research of Λ hypernuclei with high quality electron beam at Jefferson Lab

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An investigation of the baryon-baryon interaction (BB) which is extended from the well studied nucleon-nucleon (NN) interaction is one of important topics in nuclear physics. A study of the hyperon-nucleon (YN) interaction can be a first step of the extension to the understanding of the BB interaction. However, experimental data of the YN scattering are scarce since the lifetimes of hyperons are short (e.g. $\tau \simeq 2.6 \times 10^{-10}$ s for Λ hyperon). Therefore, the YN interaction have been investigated mainly by studying hypernuclear structures. Many species of Λ hypernuclei (Λ is the lightest hyperon) have been spectroscopically studied until now. Moreover, a Λ can be bound in deeply inside of a nucleus since a single embedded Λ is not subject to the Pauli exclusion principle from nucleons. It means that a Λ can be a probe to investigate deeply inside nucleus where is not easily studied by spectroscopy of normal nuclei.

In the 20$^{\text{th}}$ century, various hypernuclei up to $A = 209$ were investigated by the (K^-,π^-) and (π^+,K^+) reactions at CERN, BNL and KEK. Since 2000, Λ hypernuclear spectroscopy with the (e,e′K^+) reaction has been performed at Jefferson National Accelerator Facility (JLab) in the United States. Currently, Λ hypernuclear spectroscopy with the (e,e′K^+) reaction can be performed only at MAMI and JLab in the world. A sub-MeV energy resolution (FWHM) can be achieved in (e,e′K^+) experiment thanks to high quality and high intensity primary electron beam in contrast to a few MeV energy resolution (FWHM) in (K^-,π^-) and (π^+,K^+) experiments. Thus, finer structures which cannot be studied with existing meson beams can be investigated with the (e,e′K^+) reaction. In addition, an absolute energy calibration can be performed with Λ and Σ^0 in (e,e′K^+) experiment since a p is converted to a Λ. On the other hand, a reported value of ${}^{12}_{\Lambda}$C (an averaged value of six events in emulsion experiments) has been used as a reference for binding energy measurement in the (π^+,K^+) experiments.

In the presentation, an overview of Λ hypernuclear spectroscopy with the (e,e′K^+) reaction will be given. Then, the latest results of the JLab E05-115 experiment (2009) which measured from $A = 7$ to $A = 52$ hypernuclei will be shown with discussions of the charge symmetry breaking (CSB) effect in the ΛN interaction, the single particle potential of Λ and so on. In addition, a future project of Λ hypernuclear spectroscopy at JLab and the decay π^+ spectroscopy at MAMI will be introduced. Importance of Λ hypernuclear measurements with both the (e,e′K^+) reaction at JLab and the (π^+,K^+) (and (K^-,π^-)) reaction at J-PARC in complementary ways will be also mentioned.