# Gamma-ray spectroscopy of $\Lambda$ hypernuclei at J-PARC

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Gamma-ray spectroscopy of hypernuclei with a few-keV energy resolution of Germanium detectors uncovered level structures of several p-shell $\Lambda$ hypernuclei. These data have uniquely shed light on the spin-dependent part of $\Lambda$N interaction. Moreover, experimental data on $\Lambda$N scattering is limited due to its technical difficulties and there is a lack of direct informations on the bare $\Lambda$N interaction. Thus level structures of hypernuclei provide a testing ground for models of YN interaction. Another important aspect of the $\Lambda$-hypernuclear $\gamma$-ray spectroscopy is to investigate an interplay between the $\Lambda$ particle and the core nucleus. A sizable core polarization effect of a $\Lambda$ particle induced by its glue-like character was experimentally observed in ${}^{7}_{\Lambda}$Li for the first time through a measurement of a reduced transition probability, $B(E2)$. These progresses were achieved by the successful construction of the large Ge detector array, Hyperball in 1998 and Hyperball-2 in 2005 and a series of experiments using them at BNL and KEK via the $(K^-, \pi^-)$ and $(\pi^+, K^+)$ reactions.

However, the existing data cover only a small portion in the hypernuclear chart that can be studied via the $\gamma$-ray spectroscopy. Currently $\gamma$ rays beyond the p-shell hypernuclei has not been identified. The next higher shell to be studied will naturally be the sd-shell. The number of valence protons and neutrons outside the doubly closed $^{16}$O core are much larger than that in the p-shell. Therefore, the level structures of the sd-shell hypernuclei will be richer and more complex. Especially the mid-shell nuclei such as Mg are known to be well deformed and exhibit collective behaviours. It would be important to verify if any changes in collectivities occur by the presence of $\Lambda$ particle. Another lack of spectroscopic information is electromagnetic properties of the excited levels, namely, the reduced transition probabilities such as $B(E2)$ and $B(M1)$, the latter of which has never been measured thus far.

At J-PARC, a new Ge array, Hyperball-J, which is being constructed together with a greatly modified magnetic spectrometer system, will be used to tackle these challenges. For instance, the $\gamma - \gamma$ coincidence will be possible with an increased photo peak efficiency of $\sim$6 % that is essential in resolving the decay schemes of the sd-shell hypernuclei.

In this contributions, physics themes accessible via the hypernuclear $\gamma$-ray spectroscopy at J-PARC and the current status of the Hyperball-J systems will be presented.