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Proton asymmetry in non-mesonic weak decay of light hypernuclei

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Abstract

We have obtained the decay asymmetry parameters in non-mesonic weak decay of polarized Λ-hypernuclei by measuring the proton asymmetry. The polarized Λ-hypernuclei, ${}^{5}_{\Lambda}$He, ${}^{12}_{\Lambda}$C, and ${}^{11}_{\Lambda}$B, were produced in high statistics via the (π^+, K^+) reaction at 1.05 GeV/c in the forward angles.

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Preliminary analysis shows that the decay asymmetry parameters are very small for these s-shell and p-shell hypernuclei.

1. Introduction

The non-mesonic weak decay (NMWD: $\Lambda N \to nN$) of Λ-hypernuclei gives us a very unique opportunity to study baryon–baryon weak interaction. There exist several experimental observables; life times (total decay rates), branching ratios ($\Gamma(\Lambda p \to np)$, $\Gamma(\Lambda n \to nn)$), etc. The asymmetry parameter of decay proton from the $\Lambda p \to np$ process, α_p^{NM}, is another important observable to investigate the reaction mechanism of NMWD, because it comes from the interference between the parity-conserving and parity-violating amplitudes.

The decay angular distribution of protons from the NMWD of polarized hypernuclei, $W(\theta)$, is expressed as

$$W(\theta) = 1 + A\cos\theta = 1 + \alpha P_\Lambda \cos\theta, \tag{1}$$

where A is the asymmetry, P_Λ denotes the polarization of a Λ-hypernucleus, and θ means the emission angle of protons with respect to the polarization axis.

So far, two experiments reported the asymmetry parameters of NMWD for ${}^{12}_{\Lambda}$C [1] and ${}^{5}_{\Lambda}$He [2]. In KEK-PS E160, a large negative α_p^{NM} of -1.3 ± 0.4 was observed for p-shell hypernuclei [1], while the α_p^{NM} of ${}^{5}_{\Lambda}$He was measured to be 0.24 ± 0.22 by KEK-PS E278 [2]. There is a large discrepancy between these two values, which might suggest the difference of the reaction mechanisms for NMWD between s-shell and p-shell hypernuclei. However, it would be too early to draw conclusions when taking account of the statistical significance of the data and the systematic errors between two different measurements. Thus, a new measurement with improved statistics and better systematic errors was awaited.

2. Experiments: KEK-PS E462 and E508

From year 2000 to 2002, we performed two series of experiments to measure the NMWD of ${}^{5}_{\Lambda}$He (E462) and ${}^{12}_{\Lambda}$C (E508) in the K6 beamline at the KEK 12 GeV PS with the high-resolution and large-acceptance SKS spectrometer. The (π^+, K^+) reactions at 1.05 GeV/c were used to produce highly-polarized Λ hypernuclei with respect to the horizontal reaction plane. Two decay counter systems were installed symmetrically above and below the target to detect decay protons from NMWD. Each system consisted of a set of drift chambers, two sets of timing counters and a neutron counter array with six layers of plastic counters.

Fig. 1 shows the excitation energy spectra of ${}^{5}_{\Lambda}$He (left) and ${}^{12}_{\Lambda}$C (right) in three different conditions: from top to bottom, inclusive spectra, those with a pion coincidence, and with a proton coincidence. We succeeded to detect 52 000 events of the ${}^{5}_{\Lambda}$He ground state and