Gamma-Ray Spectroscopy of Hypernuclei in ^{16}O $(K^-, \pi^-\gamma)$ Reaction

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Spectroscopy of Λ hypernuclei has played an important role in study of Λ N interaction. The effective Λ N interaction can be written as

$V_{\Lambda N} = V_0(r) + V_\sigma(r)\boldsymbol{s}_N\boldsymbol{s}_\Lambda + V_\Lambda(r)\boldsymbol{l}_{N\Lambda}\boldsymbol{s}_\Lambda + V_N(r)\boldsymbol{l}_{N\Lambda}\boldsymbol{s}_{\ N} + V_T(r)\mathbf{S}_{12}$ [1].

For p-shell hypernuclei radial integrals of these five terms are usually denoted as $\bar{V}$, Δ, S_Λ, S_N and T. So far, Δ, S_Λ and S_N out of four Λ N spin-dependent interaction terms have been determined experimentally [2][3]. However, no past experiment gives information on the tensor force term, T.

The splitting of the ground state doublet for the $p_{1/2}$-shell hypernuclei has a large contribution of the tensor term. The $^{16}_{\Lambda}$O and $^{15}_{\Lambda}$N ground state doublet spacings are expressed as

$^{15}_{\Lambda}$N: $E(\frac{3}{2}^+) - E(\frac{1}{2}^+) = -0.758\Delta + 2.235S_\Lambda - 0.048S_N + 9.886T$

$^{16}_{\Lambda}$O: $E(1^-) - E(0^-) = -0.387\Delta + 1.382S_\Lambda - 0.005S_N + 7.82T$

respectively, according to a recent calculation by D. J. Millener. $^{16}_{\Lambda}$O can be produced by direct reaction such as ^{16}O (K^-, π^-) reaction, while $^{15}_{\Lambda}$N can be produced from excited states of $^{16}_{\Lambda}$O via proton emission.

In the fall of 2001 (2nd cycle of BNL-AGS E930), we performed a high resolution γ-ray spectroscopy experiment by ^{16}O(K^-, π^-) reaction using Hyperball in order to determine the tensor force strength of Λ N interaction. Hyperball, a large acceptance Ge detector array, contains 14 sets of Ge detectors surrounded by BGO scintillation counters and readout electronics specialized for high counting rate [4]. We measured incident K^- and scattered π^- momenta by magnetic spectrometers to tag the production of $^{16}_{\Lambda}$O hypernuclei.

In a preliminary analysis, we observed two γ-ray lines at about 6.5 MeV when the bound state region of $^{16}_{\Lambda}$O is gated. They are candidates of γ-rays from the excited state 1^-, the core excited state (^{15}O $(1/2^-)$: 6.2 MeV) coupled to $0s$ Λ, to the ground state doublet 1^- and 0^-. We also observed 3 γ-ray lines when an excited region of $^{16}_{\Lambda}$O over the proton emission threshold is gated. They are candidates of γ-rays from $^{15}_{\Lambda}$N.

The energy spacing of the $^{16}_{\Lambda}$O ground state doublet, which is found to be less than 50 keV (preliminary), will allow us to extract the strength of the tensor force for the first time.

References

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