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Observation of hypernuclear fine structure in $^{16}_{\Lambda}$O

E930 '01 Collaboration

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Abstract

We observed two γ-ray transitions of $^{16}_{\Lambda}$O in the ^{16}O$(K^-, \pi^-\gamma)$ reaction using a germanium detector array, Hyperball. The γ rays are assigned as the M1 transitions from the 6 MeV excited state (1^-) to the ground state doublet $(1^-, 0^-)$. The energies of the γ rays are 6534.1 ± 1.5 keV and

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6560.2 ± 1.3 keV, and the energy spacing is 26.1 ± 2.0 keV, which corresponds to the ground state doublet spacing. From their yield ratio of 0.65 ± 0.11 ($N(6534)/N(6560)$), the spin order of the ground state doublet is determined. This result gives a small value for the ΛN tensor force strength.

1. Introduction

The excitation energies of low-lying levels in the p-shell hypernuclei are determined by the ΛN spin-dependent interactions. They are described with four parameters, Δ, S_Λ, S_N and T [1], namely, the radial integrals for $p_N s_\Lambda$ interaction on the spin–spin force, the Λ-spin-dependent spin–orbit force, the N-spin-dependent spin–orbit force and the tensor force of the ΛN effective interaction, respectively. These parameters are taken to be approximately constant throughout the shell. Past experiments using Hyperball determined the values of Δ, S_Λ and S_N [2,3]. The ground state doublet spacing of the $p_{1/2}$-shell hypernuclei, such as ${}^{16}_{\Lambda}$O, has a large contribution from the tensor term. In the case of ${}^{16}_{\Lambda}$O, the energy spacing of the ground state doublet is described as:

$$E(1^-) - E(0^-) = -0.38\Delta + 1.38S_\Lambda - 0.005S_N + 7.8T + \Lambda\Sigma, \quad (1)$$

where $\Lambda\Sigma$ is the shift energy from the Λ–Σ coupling effect [4]. Meson exchange models predict the strength of the tensor force, T, to be 20–60 keV through G-matrix calculations [9]. This small value is explained by the prohibition of one pion exchange due to isospin conservation. Using the values of $\Delta = 468$, $S_\Lambda = -13$ and $S_N = -444$ keV from experiments, of $\Lambda\Sigma = -30$ keV from [4], and from meson exchange models, the ground state doublet spacing of ${}^{16}_{\Lambda}$O is estimated to be −50–+150 keV. Fig. 1 shows the low-lying level scheme of ${}^{16}_{\Lambda}$O. Both 1^- states can be produced by the (K^-, π^-) reaction.

2. Experiment and analysis

We performed a γ-ray spectroscopy experiment of ${}^{16}_{\Lambda}$O (E930 '01) at the BNL D6 beam line [6]. The 6 MeV excited state of ${}^{16}_{\Lambda}$O(1^-_2) was produced by the ^{16}O(K^-, π^-) reaction

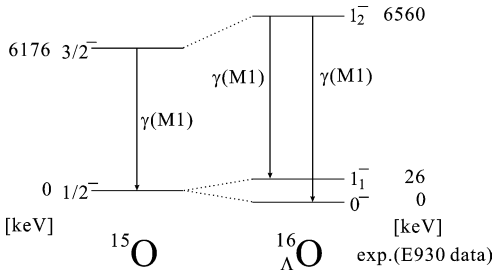

Fig. 1. Low-lying level scheme of ${}^{16}_{\Lambda}$O. Both 1^- states are populated by 0.93 GeV/c (K^-, π) reaction. Excitation energies (preliminary) are measured from the present experiment E930 '01.