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Direct measurements of the lifetime of medium-heavy hypernuclei

(HKS (JLab E02-017) Collaboration)

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Abstract

The lifetime of a Λ particle embedded in a nucleus (hypernucleus) decreases from that of free Λ decay mainly due to the opening of the $\Lambda N \to NN$ weak decay channel. However, it is generally believed that the lifetime of a hypernucleus attains a constant value (saturation) for medium to heavy hypernuclear masses, yet this hypothesis has been difficult to verify. This paper presents a direct measurement of the lifetime of medium-heavy hypernuclei that were hyper-fragments produced by fission or break-up from heavy hypernuclei initially produced with a 2.34 GeV photon-beam incident on thin Fe, Cu, Ag, and Bi target foils. For each event, fragments were detected in coincident pairs by a low-pressure multi-wire proportional chamber system. The lifetime was extracted from decay time spectrum formed by the difference of the time zeros between the pairs. The measured lifetime from each target is actually a statistical average over a range of mass with mean about 1/2 of the target mass and appears to be a constant of about 200 ps. Although this result cannot exclude unexpected shorter or longer lifetimes for some specific hypernuclei or hypernuclear states, it shows that a systematic decrease in lifetime as hypernuclear mass increases is not a general feature for hypernuclei with mean mass up to $A \approx 130$. On the other hand, the success of this experiment and its technique shows that the time delayed fissions observed and used by all the lifetime measurements done so far on heavy hypernuclei could likely have originated from hyper-fragments lighter than the assumed masses.

Keywords: Hypernuclei; Lifetime; Fragment; Hyper-fragment; Weak decay

1. Introduction

The Λ hypernucleus was discovered in an emulsion experiment in 1952 [1,2]. Since then, there have been extensive investigations of Λ hypernuclei, using various reactions and detection methods, to study the ΛN interactions (strong or weak) as well as the role of the Λ in the nuclear medium. These have illuminated hypernuclear spectroscopy, branching ratios, and decays.

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