A STUDY OF THE DECAYS
OF
HEAVY HYPERNUCLEI

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SYNOPSIS

It is now widely accepted that heavy hypernuclei of mass $A \gg 10$, are produced copiously as spallation products in K^- interactions with emulsion nuclei. These hypernuclei (D.S. events) usually have very short ranges (Range $< 10\ \mu m$), and their mass and charge can seldom bd identified uniquely in an individual event. Such hypernuclei decay predominantly through the non-mesic mode where the bound Λ^0 is transformed into a nucleon releasing about 150 MeV energy in the process. The theoretical estimate for the branching ratio of non-mesic to mesic decays of such hypernuclei is of order 100 : 1. The experimental value (200-300) is quite uncertain because there are some basic difficulties in identifying non-mesic decays (determining this parameter). On the other hand direct information on the dominant non-mesic decay rate, . $\Gamma_{\text{non-mesic}}$ may be obtained from the lifetime of heavy hypernuclei so that it is of considerable interest to determine such lifetimes experimentally. The present work describes a method for making an estimate of this parameter. A forward to backward asymmetry, in the angular distribution of short recoil tracks (less than about 5 μm in range) emitted from hypernuclear decays with respect to the track of the decaying hypernucleus has been observed. It is argued that this asymmetry arises because a considerable fraction of these hypernuclei decay in flight. It is,

therefore, possible to estimate the lifetime of the hypernuclei from the observed anisotropy of the recoils. Two stacks of K5 emulsion, exposed to 1.5 and 3.5 GeV/c K^- beam at the CERN synchrotron, have been used for measurements. Measurements have also been made on two other stacks exposed to stopping K^- beam. In 1.5 GeV/c K^- stack about 500 separable short range hypernuclei have been analysed to get 173 hypernuclei with a recoil ($0.5\ \mu m \leqslant$ Range $\leqslant 5.0\ \mu m$) at the decay centre. The angular distribution of these recoils with respect to the hypernucleus direction at the decay point is observed to give a F/B ratio $= 2.6 \pm 0.4$.

Similar measurements in 3.5 GeV/c stack on 175 short range hypernuclei have yielded 62 events with a recoil at the decay centre. The F/B ratio for these recoils is observed to be 2.1 ± 0.6. In all 110 D.S. events, from K^- captures, with a suitable recoil, are studied.

A check on the reliability of the observed anisotropy is made by measuring the recoil angle distribution from π^- capture stars with similar criteria. The measured F/B ratio of these recoils with respect to π^- tracks from 228 π^- captures is 1.15 ± 0.15. This calibration experiment, along with other considerations, shows that the preferential loss in the backward direction is unlikely to be greater than about 25 per cent.

The F/B ratios after proper corrections, come out to be 2.1 $\pm$ 0.3 and 1.7 $\pm$ 0.4 in case of 1.5 and 3.5 GeV/c K^- interactions respectively. The corrected F/B ratio, as obtained from similar measurements on 87 D.S. events from K^- captures, comes out to be 1.4 $\pm$ 0.3. This value, being quite near isotropy, has also been ascertained more precisely by another method. This method involves retracing of D.S. events by measuring coordinates of a few points on each track from the decay centre. Such measurements on 110 D.S. events, showing a suitable recoil give 1.2 $\pm$ 0.2 as the corrected F/B ratio. This ratio can very well takento be consistent with isotropy.

The results of Mento Carlo calculations, taking into account the detailed features of the production and subsequent decays of short range hypernuclei, have been presented. These results are also compared with experimental ones. Estimation of lifetime for 4 samples, e.g., K^- captures, 1.5, 3.5 and combined sample of 1.5 and 3.5 GeV/c K^- interactions, are $\tau \simeq 3 \times 10^{-12}$ sec,

$$(1.0^{+0.5}_{-0.2}) \times 10^{-12} \text{sec}, \ (2.2^{+3.3}_{-0.9}) \times 10^{-12} \text{sec, and}$$

$(1.3^{+0.6}_{-0.3}) \times 10^{-12}$ sec respectively. Based upon these estimates and allowing for other errors involved, it is concluded that the lifetime of short range spallation hypernuclei lies in the range 10^{-12} - 10^{-11} sec.

This lifetime is very much shorter than the predicted value, Dalitz[11]. Assuming the theoretical value of Dalitz for the partial mesic decay rate (for heavy hypernuclei), Γmesic, the branching ratio of non-mesic to mesic decays is easily calculated from the lifetime of heavy hypernuclei. The lowest value of this ratio comes out to be about 1700, which is very much larger than the experimentally observed value. In view of this disagreement, the evaluation of Γmesic and Γnon-mesic for heavy hypernuclei have been re-examined. The suppression of mesic decay for heavier hypernuclei, due to Pauli exclusion principle has been found to depend appreciably upon the Fermi momentum i.e., the momentum upto which the nucleon states in a heavy nucleus are filled. The calculations of Γnon-mesic, depending upon the time a Λ° particle spends in the vicinity of a nucleon in the hypernucleus, yield results which do not differ appreciably from those of Dalitz.

To summarise, on the basis of such a short lifetime for heavy hypernuclei, one would expect a very much larger non-mesic to mesic branching ratio than hitherto observed. In view of this, it would be worthwhile to determine this branching ratio more carefully, Further, the calculations of Dalitz indicate that the non-mesic rate in $_{\Lambda}He^{5}$ is about the same order of magnitude as the free decay rate of the It is, therefore, surprising that the rate should be so much enhanced for heavy hypernuclei; so a more complex phenomenon may have to be invoked for the non-mesic de-excitation of the Λ° hyperon in a large hypernucleus.

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