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THE CROSS SECTION FOR PRODUCTION OF HYPERNUCLEI IN EMULSION BY 9-Bev PROTONS

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The cross section for the production of hypernuclei in NIKFI-R photographic emulsion exposed to 9-Bev protons is found to be $\sigma_{Hf} = (0.2 \pm 0.1)$ mb.

1. INTRODUCTION

A number of articles on hypernuclei have already been published. These articles deal mainly with the study of the decay of hypernuclei stopping in photographic emulsion. As a result, many valuable data have been obtained on the properties of Λ^0 particles in the bound state and on the character of the Λ^0N interaction. Only some of the articles (see for example, [1]) deal with questions connected with the mechanism of hypernucleus production. The study of the act of production of hypernuclei can give valuable information on strong interactions of nucleons in which strange particles are produced and on the character of the interaction of strange particles with each other, with nucleons, and with π mesons. Qualitative ideas on the mechanism of hypernucleus production are based on the assumption that the formation of hypernuclei is preceded by the production of Λ^0 particles along with other strange particles, and, possibly, π mesons in the elementary act of NN interactions. It is natural to begin a study of the mechanism of hypernucleus production with the determination of their production cross section and the dependence of this cross section on the energy of the bombarding protons. Blau[2] and Fry et al[3] have determined the frequency of production of hypernuclei by 3- and 6-Bev protons. In this article, we shall present an estimate of the cross section for this process in the case of 9-Bev protons.

2. EXPERIMENTAL METHOD

A stack of 400-μ NIKFI-R emulsion pellicles was exposed to 9-Bev protons from the proton synchrotron of the Joint Institute for Nuclear Research. The primary proton flux, estimated from a direct count of tracks over successive 34-μ intervals, 500 μ apart, with allowance for the change in thickness of the pellicle, was $(1.36 \pm 0.06) \times 10^5$ cm^{-2}. The emulsion was scanned under a magnification of $20\times1.5\times10$. All double stars were recorded. After scanning part of the material a second time and taking into account the geometrical conditions of observation of the stars and the connecting tracks, we were able to estimate the scanning efficiency on the basis of double stars missed in the scanning. In the entire scanned volume, 443 double stars were observed (without taking into account L-shaped tracks). They were all analyzed with a view to selecting hypernuclei.

The analysis was based on the laws of conservation of energy, momentum, and charge of the particles with the best possible determination of the charge, and measurement of the track lengths and angles between tracks. The charge was determined by the track-width method.*

In selecting the cases with hypernuclei from among the double stars, we excluded all cases of interaction of π^- and K^- mesons with nuclei on the basis of the law of conservation of charge; elastic pp interactions were eliminated by means of the law of conservation of momentum. Interactions between nuclei and emulsion nuclei were distinguished from hypernucleus decays by the track-width measurements. The thinning down of the connecting track was evidence of the stopping of the particle. Cases in which there was no thinning down of the connecting track were attributed to nuclear-nuclear interactions. In about 2% of the cases, the measurements could not give information on the thinning down (tracks $\leq 20\,\mu$ in length).

3. RESULTS

As a result of the analysis of all double stars, 20 cases were attributed to hypernuclei: 18 with nonmesic decay and 2 with mesic decay. It should be noted that we did not take into account cases

*Details on the track-width measurements in NIKFI-R emulsion will be presented in a separate report.

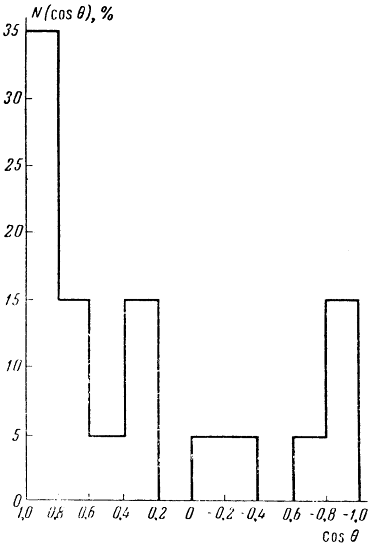
with L-shaped tracks, which are (except for scatters) either nonmesic decays of hypernuclei with Z = 1, 2 or π^0-mesic decays. These cases were very rare, and, in our opinion, do not make any essential contribution to the value of the cross section.

Most hypernuclei have a charge ≥ 3. The charge distribution was as follows:

Z:	1	2	3	>3
Number of hypernuclei:	2	3	6	9

The mean number of gray and black tracks in the parent stars with hypernuclei was 14 ± 1.4. This gives a basis to assume that all observed hypernuclei are produced as a result of the interaction of primary protons with heavy nuclei of the emulsion (Ag and Br).

The angular distribution of the hypernuclei (see figure) indicates that the direction of emission is preferentially in the forward hemisphere (i.e., in the direction of the primary proton. The ratio of the number of cases of forward emission to the number of cases of backward emission was 2.3, which is in good agreement with the data given in Silverstein's survey.[1]



4. DISCUSSION OF RESULTS

The cross section determined by us, after all corrections, was $\sigma_{Hf} = 0.2 \pm 0.1$ mb.

If we compare this value with the cross section for the production of free Λ^0 particles,[4] then it turns out that $\sigma_{\Lambda^0}/\sigma_{Hf} \approx 15$. This apparently indicates that only a small part of the produced Λ^0 particles give rise to hypernuclei. Blau[2] and Fry et al[3] at 3 Bev and 6 Bev, respectively, observed 14 and 7 hypernuclei out of 14 480 and 10 000 stars; the corresponding frequencies of hypernuclei per star were 1×10^{-3} and 0.7×10^{-3}. Comparison with our data indicates that the hypernucleus production cross section in the 3 — 9 Bev region decreases with an increase in the primary proton energy. In all probability, this decrease in cross section is connected with the decrease in the cross section for NN interactions[5] and the decrease in cross section for the production of Λ^0 particles with an increase in energy of the primary nucleon.

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[6] Barashenkov, Barbashov, and Bubelev, Statisticheskaya teoriya mnozhestvennogo rozhdeniya pri stolknovenii bystrykh nuklonov (Statistical Theory of Multiple Production in the Collision of Fast Nucleons), Preprint, Joint Institute for Nuclear Research, 1958.

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