Search for $S=-2$ Negative Heavy Meson in Nuclear Emulsions

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A search for the D^- meson was conducted in an emulsion stack exposed to the 300-Mev/c K^- beam at Berkeley. The stars initiated by the beam particles were investigated for possible emission of two strangeness-carrying particles, and in addition mass measurements were done on the short-range tracks. In about 10 000 events examined, no possible $S=-2$ particle has been observed. Hence the upper limit for the D^--meson occurrence in the present experimental conditions is $\sim$1/100 from the double strangeness observation and $\sim$1/6000 from direct mass determinations.

RECENTLY, an unusual example of an interaction of a "heavy" K^- meson in nuclear emulsions was published.[1,2] Since both a Σ^+ hyperon and a possible hyperfragment emerged from the interaction point, the event was interpreted as due to a nuclear absorption of a negative particle (named D^- meson in references 1 and 2), having a strangeness quantum number -2. At the same time a possible example of a positive D meson was discussed by Wang Kang-Chang.[3]

A search for the D^- meson was conducted in an emulsion stack exposed to the 300-Mev/c K^- beam at Berkeley.[4] Since the ionization of the D^- meson at the entrance to the stack is expected to be only 30–50% larger than the K^- ionization, the D^- would have been picked up by the scanners.

The present work was performed in two stages: (1) search for stars emitting two visible strangeness-carrying particles, namely the reactions $D^-+\text{nucleus}\rightarrow\Sigma+\Sigma$, $\Sigma+$hyperfragment, hyperfragment+hyperfragment, K^-+hyperfragment, or $K^-+\Sigma$; (2) direct mass determination of short-range particles coming to rest in the stack and producing a typical capture star.

The procedure which we have employed in the first stage was as follows: In a scan (along-the-track) of the above stack about 8000 K^- stars were found. From these stars, about 800 Σ hyperons and clear hyperfragments were observed. We have then traced all the grey and black prongs emitted from the above 800 stars, and searched for possible other Σ's and hyperfragments The same procedure was repeated for the stars at flight from which a K^- was seen to re-emerge. No clear example of any of the above 5 possible reactions of D^- was observed. In a few cases, in addition to a hyperon or hyperfragment, a short track gave rise to a capture star. These were all consistent with being slow π^- mesons. In a few other cases, the secondary tracks (clear baryons) from the 800 stars were deflected before coming to rest, or had an associated blob at their end. In order to check this point, we have examined the endings of 100 protons emitted from $\Sigma^+\rightarrow p$ decays. The behavior of the baryons emitted from the 800 K^- stars, containing one clear Σ or hyperfragment, resembled very much, in all respects, the behavior of the protons from Σ^+ decay. Nothing unusual was found. Since the lightly ionizing particles ($g^*\lesssim 2.5$) emitted from the above 800 stars were not followed, this method searching is valid for $M_{D^-}\lesssim 750$ Mev.

In the second stage of this work we have looked at the range distribution of all the particles which came to rest in the emulsion block (see Fig. 1). For a 300-Mev/c momentum, the expected range of a K meson is 37 mm; the range of a 650-Mev mass particle should be $\sim$21 mm of emulsion and protons would stop after about 8 mm. The experimental histogram of about

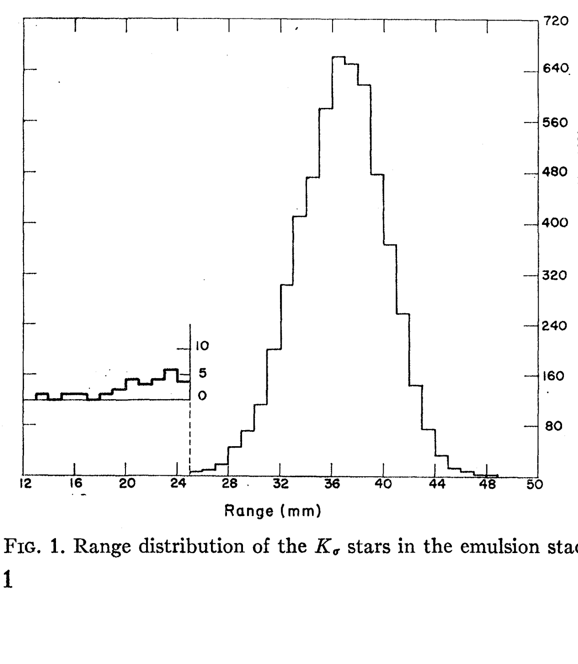

FIG. 1. Range distribution of the K_σ stars in the emulsion stack.

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[2] T. Yamanouchi, Phys. Rev. Letters **3**, 480 (1959).

[3] Wang Kang-Chang, International Conference on High-Energy Physics, Kiev, 1959 (unpublished).

[4] The present search was conducted in a stack exposed to the same beam [W. Barkas *et al.*, *Proceedings of the Seventh Annual Rochester Conference on High-Energy Nuclear Physics, 1957* (Interscience Publishers, New York, 1957), p. VI-12] in which the Yamanouchi and Kaplon stack was exposed.

6000 K_σ^- events (K^- capture stars at rest, giving rise to at least one secondary particle) is shown in Fig. 1. The main body of the K^- beam (~99%) indeed stops at the expected position (corresponding to an entrance momentum of 300±10 Mev/c), with a tail in both the high- and low-range sides. All the particles having a range less than 25 mm were more critically examined. Entering pions (13 events) and protons (1 event) were immediately removed from the analysis. On all the rest of the short-range tracks (see Fig. 1), careful ionization measurements were performed, using as reference tracks K^- mesons from the main body of the K^- beam. The measurements showed that all the short-range tracks were due to ordinary K^- mesons. Again, nothing unusual was observed.

In conclusion, we wish to give the upper limit for the frequency of occurrence of the D^- meson obtained in the present work, under the experimental conditions as described in reference 4. From the search for double strangeness release, the upper limit is about 1% (since the probability for single Σ or hyperfragment observation in K^- capture is about 10%). From the direct mass measurement, however, the upper limit is ~1/6000.

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Internal Pairs Following π^- Capture in Hydrogen*

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Internal electron pairs from the two reactions (1) $\pi^-+p\rightarrow n+\pi^0\rightarrow n+\gamma+e^++e^-$ and (2) $\pi^-+p\rightarrow n+e^++e^-$ have been studied in a hydrogen bubble chamber. 2184 cases were seen. A geometrical cutoff selected 1523 of these as suitable for momentum measurement. By an analysis of the momentum spectrum, the Panofsky ratio was measured to be 1.51±0.10. The total intensity, momentum partition within the pairs, and distribution in virtual photon mass are in essential agreement with the theoretical predictions of Kroll and Wada as recently extended by Joseph.

INTRODUCTION

THE original experiment on the absorption of negative pions by hydrogen[1] provided several results which were crucial to pion physics. When a negative pion comes to rest in liquid hydrogen it is captured into a mesonic hydrogen atom and absorbed from an s state[2] by the proton. The time from atomic capture to nuclear absorption is about 10^{-12} sec [2,3] which is very much shorter than the decay time of 2.5×10^{-8} sec, so almost all the mesons are absorbed. This absorption was shown experimentally to lead to two reactions:

$$\pi^-+p\rightarrow n+\pi^0, \quad (1)$$

$$\pi^-+p\rightarrow n+\gamma. \quad (2)$$

The ratio between the rates of these two reactions,

$$P=w(\pi^-+p\rightarrow n+\pi^0)/w(\pi^-+p\rightarrow n+\gamma),$$

which is now called the Panofsky ratio, was measured to be 0.94±0.3. Since this ratio provides a link between the zero-energy charge-exchange scattering and photoproduction of π mesons,[4,5] several later and better measurements have been made. These are summarized in Table I.[1,6–9]

The results do not seem statistically compatible. All of the experiments in Table I were performed with

TABLE I. Results of previous measurements of the Panofsky ratio.

Author	Result
Panofsky *et al.*, reference 1	0.94±0.3
Cassels *et al.*, reference 6	1.50±0.15
Kuehner *et al.*, reference 7	1.60±0.17
Fisher *et al.*, reference 8	1.87±0.10
Koller *et al.*, reference 9	1.46±0.10

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