K⁻ INTERACTIONS IN DEUTERIUM

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I would like to spend a few minutes describing an experiment performed several weeks ago at the Bevatron involving the interaction of K^- mesons with deuterium. The experiment was done with the 15 inch chamber of the Alvarez group and the same people mentioned by Kaplon in connection with the K^--hydrogen experiment are associated with the work.

There are several reasons why $K^- - D$ capture is of interest in strange particle physics. One is the possibility of the formation of a mass 2 hyperfragment. Another is to test charge independence, and a third is to study the K^--neutron interaction.

We now have about 1 500 K^- interactions in deuterium. So far we have had time to look at only a fraction of these events and have classified them essentially by inspection, and not by any detailed analyses (we are now in the process of doing this).

Therefore the data is preliminary, but we feel sufficiently trustworthy to report.

The bubble chamber is the same as used for the hydrogen experiment, except filled with deuterium. The operating conditions are similar to hydrogen. The K^- beam is also the same and since it has been quite successful for K^- and anti-protons, I would like to show a slide of the layout for those interested in beamology. (See Fig. 29.)

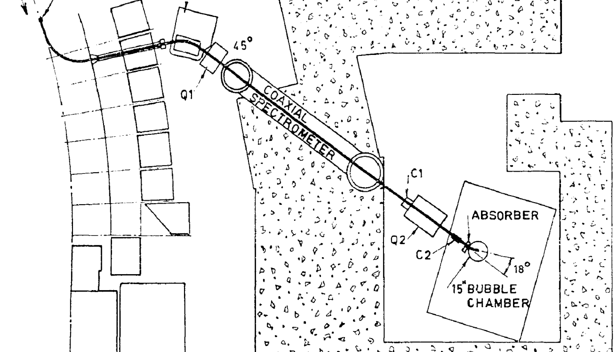

Fig. 29. *Experimental arrangement of the* 15-*inch bubble chamber for studying* K^- *interactions in hydrogen and deuterium. (Berkeley group)*

The 450 MeV/c beam is momentum analysed by the Bevatron field. A second momentum analysis removes the dispersion of the beam introduced by the first bend. The beam then passes through the Murray electrostatic separator where the pions are deflected outward and the K's are transmitted undeflected. The separator is a long cylinder with a radial electric field and a perpendicular magnetic field generated by a current flowing down a central conductor. The K's are focussed by quadrupoles and made to pass through a tiny aperture and then fan out into the bubble chamber. The rejection ratio is 650, and we have one K^- in the chamber per 70 background tracks (mostly muons).

The K's are almost unambiguously identified in the chamber by their characteristic curvature and high ionization. The decay of a hyperon in most cases of K^- interaction, confirms the identification.

We stopped the tabulation at 274 K's and Table III shows the result. (See Table III.)

The number of " K decays " is consistent with the K lifetime. The observed number has been corrected slightly for $K^- - D$ reactions which sometimes look like K decays.

$\Sigma^{\pm}$ are Σ's which are so short that we cannot distinguish the decay pion from the production pion and thus cannot tell the sign. Y^0 means either Λ^0 or Σ^0. In the $Y^0 - \pi^- - p$ events we shall be able to distinguish the two cases when we measure the events. In the $Y^0 - \pi^0 - n$ events the spectra overlap so the separation will not be clean.

" K_Q " are principally $Y^0 - \pi^0 - n$ events and are consistent with that number. There is only one clear case of non-mesonic capture. There may be a few more when we measure the events—but the number seems small as expected theoretically.

We have seen no evidence for hyperfragment formation among these events. Three kinds are possible $(\Sigma^- - n)$, $(\Lambda^0 - n)$, $(\Lambda^0 - p)$. The latter two are already convincingly ruled out by extrapolation of the binding energy vs atomic weight (A) curve to $A = 2$. The $(\Sigma^- - n)$ case could well have existed. Pais and Treiman have calculated that if the binding energy is greater than 100 KeV or so, then there would be large probability for its formation in K^- capture, for either S- or P-state capture and pseudo-

TABLE III

K^--Deuteron Interactions (Bubble Chamber).

Final State	No Observed	Final State	No Observed
" K decay "	37	$\Sigma^- + \pi^0 + p$ and $\Sigma^- \to \pi^- + n$	7
$\Sigma^\pm + \pi^\mp + n$ and $\Sigma^\pm \to \pi^\pm + n$	12	$\Sigma^- + \pi^+ + n$ and $\Sigma^- \to \pi^- + n$	43
$\Sigma^+ + \pi^- + n$ and $\Sigma^+ \to \pi^+ + n$	21	$\Sigma^- + \pi^+ + n$ and $\Sigma^- + D \to Y^0$ and $Y^0 \to \Lambda^0 \to \pi^- + p$	4
$\Sigma^+ + \pi^- + n$ and $\Sigma^+ \to \pi^0 + p$	17	$\Sigma^- + \pi^+ + n$ and $\Sigma^- \to \Sigma_\varrho$	2
$Y^0 + \pi^0 + n$ and $Y^0 \to \Lambda^0 \to p + \pi^-$	48	K_ϱ	33
$Y^0 + \pi^- + p$ and $Y^0 \to \Lambda^0 \to p + \pi^-$	30	$\overline{\theta^0} + n + n$ and $\overline{\theta^0} \to \pi^+ + \pi^-$	1
$Y^0 + \pi^- + p$ and $Y^0 \to \Lambda^0 \to \pi^0 + n$	18	$\Lambda^0 + n$ and $\Lambda^0 \to \pi^- + p$	1

scalar or scalar K. Since no likely candidates for a $(\Sigma^- - n)$ hyperfragment have been seen among 54 $\Sigma^- - \pi^+ - n$ events then either the binding energy is extremely small or the $(\Sigma^- - n)$ hyperfragment does not exist.

The Λ^0-nucleon hyperfragment is also not seen among a comparable number of events.

Since the $K^- - D$ system is initially in a pure I-spin $= \frac{1}{2}$ state, a number of relations can be written relating various possible final states. These always require distinguishing a Λ^0 from a Σ^0, which we cannot do without careful analysis of the event. Fortunately, however, one can combine the relations in such a way that only the sum of Λ^0 and Σ^0 appear so that they need not be distinguished.

The two relations given below should be equal if I-spin is conserved for Σ and Λ production. Within statistics it seems to hold.

The relations used to test conservation of I-spin are: Branching ratio for charged mode of decay of Λ assumed to be 0.60 ± 0.04

$$\tfrac{1}{2}\left[R(\Sigma^+ + \pi^- + n) + R(\Sigma^- + \pi^+ + n) + R(\Sigma^0 + \pi^- + p) + R(\Lambda^0 + \pi^- + p)\right] = 75 \pm 4$$

$$R(\Sigma^- + \pi^0 + p) + R(\Sigma^0 + \pi^0 + n) + R(\Lambda^0 + \pi^0 + n) = 87 \pm 13$$

Assuming I-spin conservation and a *crude* impulse approximation (no interference between the $K^- - p$ and the $K^- - n$ interaction), one can go from the former tabulation to the following result.

	In deuterium total numbers	In hydrogen relative numbers
$K^- + p \to \Sigma^-$	54	8
$\to \Sigma^+$	44	4
$\to \Sigma^0$	58	4
$\to \Lambda^0$	22	1
	178	
$K^- + n \to \Sigma^-$	7	
$\to \Sigma^0$	7	
$\to \Lambda^0$	43	
	57	

Thus in this approximation:

1. The hyperon production ratios have changed significantly for K^- capture in deuterium to that observed in hydrogen. This may be due to different angular momentum states occuring in the capture.

2. Proton captures are three times more frequent than neutron captures.

DISCUSSION

Yamaguchi: How could you distinguish between proton capture and neutron capture in the deuteron?

Tripp: If we see a proton coming off then we say it was a capture on a neutron; if we do not see a proton coming off then we say it was a capture on a proton.

Yamaguchi: I do not understand. If you have a strong final state interaction you cannot distinguish them.

Tripp: We assume that there is no final state interaction.