This results in an elongation of the proton configuration and consequently decreases the Coulomb energy. This decrease is included in our model but not in the usual one.

We hope to investigate this model further.

I wish to thank Dr. R. B. Leachman, Dr. W. J. Swiatecki, and Dr. S. G. Thompson for stimulating discussions. I am indebted to Professor Manne Siegbahn for the hospitality I have received at his institute.

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Lifetime of *K* Mesons*

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SINCE the various species of *K* mesons produced at the Bevatron are found to have masses equal within the rather small experimental error,[1,2] it becomes a critical matter to see if the lifetimes of the different species are different (as one would expect if they have separate identities) or if the lifetimes are all the same (as they would be if there is but one primary *K* meson which has several alternate modes of decay). This letter describes preliminary results of a counter experiment investigating this point.

The magnet arrangement devised by Kerth and Stork[3] was used [Fig. 1(a)], with the quadrupoles set to focus an image of the target at the central counter *C*. The momentum dispersion was such that counter *C* was traversed by positive particles of 340 Mev/*c* at its right-hand end, and 400 Mev/*c* at the left end. The momentum at each point was fairly well defined, so that is was possible, by tapering the absorber between counters No. 1 and *C*, to compensate for the dispersion and bring all *K* particles incident on counter *C* to rest in *C*. Counters No. 0 and No. 1 served as beam-defining counters. At each momentum, there are about 400 protons and 40 π^+ mesons for every K^+. The protons have shorter ranges, and are stopped in the absorber between No. 1 and *C*; the π's go through *C* and through the anticoincidence counter No. 2. Since about one in six of the π's interacts in *C* and misses No. 2, No. 2 has an effective efficiency of only $\frac{5}{6}$, and was therefore augmented by a Lucite Čerenkov counter (Čer) placed in front of counter No. 1. The *K*-particle velocities are all below Čerenkov threshold, whereas the π velocities are all well above it. The Čerenkov counter

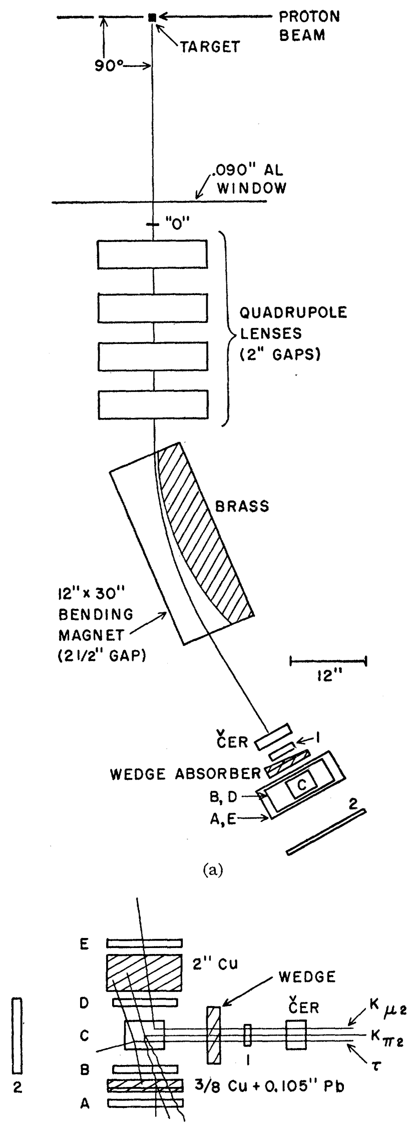

FIG. 1. (a) Top view of apparatus. (b) Side view of counter telescope.

provided a rejection factor of about 40 for π's; with both Čer and No. 2 in anticoincidence, about $40\times\frac{1}{6}\times(1/40)\cong 0.15$ π's should be counted for every *K*.

The coincidence $0+1+C-2-\text{Čer}\equiv G$ should then denote a K^+ particle stopping in *C*. Figure 2 shows the counting rate *G vs* thickness of the absorber in front of *C*. The expected peak at the range corresponding to mass$\approx 965m_e$ is present, as well as a background of $\approx 15\%$, measured at large absorber thicknesses, caused by π's.

The rise at small absorber thickness is probably caused by protons scattered from the magnet.

As a further check, a curve of *G vs* cable delay between counters 0 and $(1+C)$ was taken. This distribution was centered at the expected *K*-particle

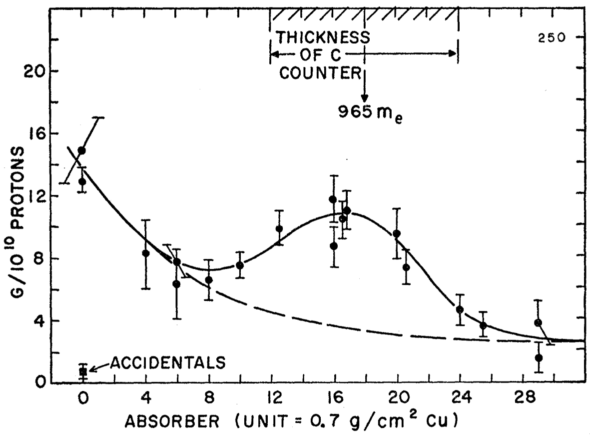

FIG. 2. K-particle range curve.

time of flight, but was too broad to be of very great use in eliminating π's.

From these facts we conclude that the G counts are chiefly caused by stopping K particles.

The identification of the individual K particles according to type, and the measurement of the lifetime of each event, is accomplished by the side-counter telescope $ABCDE$ [Fig. 1(b)].

An oscilloscope sweep is triggered by each G coincidence, and the outputs of counters A, B, C, D, and E (separated by appropriate cable delays) are displayed on the sweep. A C pulse is present on each sweep, since it is associated with the G coincidence that triggered the sweep. The lifetime is measured by observing the time delay between the C pulse and the side-counter pulses.

The $K_{\mu 2}$, $K_{\pi 2}$, and τ are identified by the following configurations:

$$K_{\mu 2}^{+}(\rightarrow \mu^{+}+\nu)=G+D+E-A-B,$$
$$K_{\pi 2}^{+}(\rightarrow \pi^{+}+\pi^{0})=G+D-E+A-B,$$
$$\tau^{+}(\rightarrow \pi^{+}+\pi^{-}+\pi^{+})=G+D-E-A+B.$$

(The two side-counter pulses on each "signature"—as D, E for the $K_{\mu 2}$—are required to be simultaneous.)

Thus the $K_{\mu 2}$ is identified by having a secondary capable of penetrating 2 inches of Cu, greater than the range of any of the $K_{\pi 2}$ or τ decay products. The $K_{\pi 2}$ is identified by having a charged secondary with range <2 inches of Cu, as well as a neutral secondary that converts in the absorber between A and B; and the τ by having at least two charged secondaries of small range. These properties are sufficiently decisive so that there will be very little confusion between the different types of K decays. Other types of K mesons are known, from emulsion experiments, to be too rare to influence our results.[4]

As a check on the reality of the signatures $K_{\pi 2}$ and $K_{\mu 2}$, the absorber between D and E was increased to more than the expected range of the μ from $K_{\mu 2}\rightarrow \mu+\nu$, and the converter between A and B was removed. When this was done the $K_{\mu 2}$ and $K_{\pi 2}$ events disappeared. A similar check on the τ's led to inconclusive results.

The raw data of the lifetime experiment are shown in Fig. 3, in the form of integral decay curves.

The lifetimes of the $K_{\pi 2}$ and $K_{\mu 2}$ are equal within the experimental error.

The lifetimes were calculated from $T=\sum t_i/N$, correcting N for a measured background of zero-time events arising from scattered π's. The scattered-proton contribution to the zero-time events is small, since coincidences involving G plus one or more side counters did not show the rise at small absorber that is seen in Fig. 2. Accidental background was negligible. This analysis gave, for the mean lives,

$$T(K_{\mu 2})=(1.4\pm 0.2)\times 10^{-8}\text{ sec},$$
$$T(K_{\pi 2})=(1.3\pm 0.2)\times 10^{-8}\text{ sec}.$$

A more accurate lifetime, for a mixture of K particles, was obtained from coincidences GD, GB, and GBA. Each of these categories corresponds to K mesons whose decay products fall in an angular range where they do not produce a signature. These events gave

$$T(K)=(1.3\pm 0.1)\times 10^{-8}\text{ sec}.$$

The GD decay curve (Fig. 3) may be fitted by a single exponential.

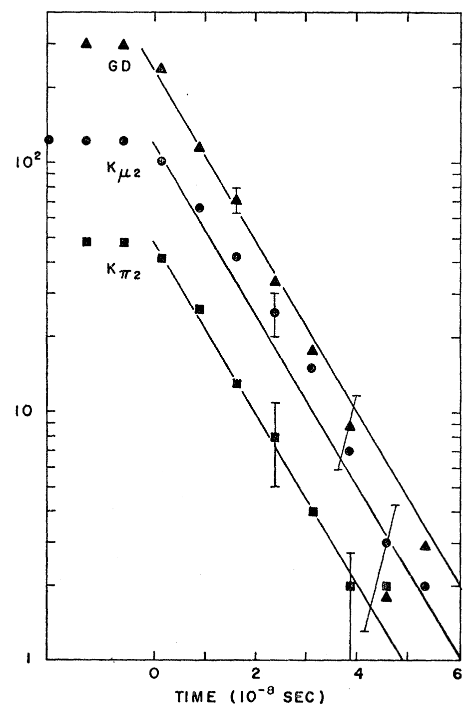

FIG. 3. Integral decay curves. Ordinates are the actual numbers of events observed, uncorrected for detection efficiencies. The data are uncorrected for zero-time contribution caused by scattered π's. The solid lines are exponentials of 1.3×10^{-8} sec decay constant, and are not necessarily best fits to the data. The decays are each well represented by a single exponential, and are consistent with equality of lifetimes for the $K_{\pi 2}$ and $K_{\mu 2}$.

Results for the less abundant τ are not yet clear-cut; however, the independent measurement by Alvarez and Goldhaber[5] gave

$$T(\tau)=(1.0_{-0.3}^{+0.7})\times10^{-8}\text{ sec},$$

which is equal, within statistics, to the above $K_{\pi2}$ and $K_{\mu2}$ lifetimes.

* This work was done under the auspices of the U. S. Atomic Energy Commission. A preliminary report of this work was presented at the Chicago Meeting of the American Physical Society [Alvarez, Crawford, Good, and Stevenson, Phys. Rev. **100**, 1264(A) (1955)].

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Branching Ratios in Hyperon and Heavy-Meson Decays

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LITTLE is known, experimentally, about the branching ratios in the decays

$$\Lambda^0\rightarrow\begin{cases}p+\pi^-\\ n+\pi^0\end{cases}\quad\text{and}\quad\theta^0\rightarrow\begin{cases}\pi^++\pi^-\\ 2\pi^0.\end{cases}$$

Actually, if it is correct that Λ^0 and θ^0 are produced jointly, e.g., in the reaction

$$\pi^-+p\rightarrow\begin{cases}\Lambda^0+\theta^0\\ \Sigma^0+\theta^0\rightarrow\gamma+\Lambda^0+\theta^0,\end{cases}$$

it would be a matter of simply counting how frequently the pair $\Lambda^0+\theta^0$ disintegrates into two charged pairs ($p+\pi^-$ and $\pi^++\pi^-$), as compared with the cases where either the Λ^0 alone, or the θ^0 alone, is seen to decay into a charged pair. With known detection efficiencies, this would immediately yield the desired information. (Of course, $\theta^0\rightarrow2\pi^0$ is forbidden for a θ^0 of odd parity.)

For the Σ^+, the two decay modes

$$\Sigma^+\rightarrow\begin{cases}n+\pi^+\\ p+\pi^0\end{cases}$$

are well substantiated, and there is evidence that the π^+ decay is favored.[1] Nevertheless, there is still considerable uncertainty about the value of the branching ratio. Another poorly known quantity is the ratio of the lifetimes of Σ^+ and Σ^-. Intuitively, one would expect Σ^- to have the longer life since it has only one mode of decay, *viz.*, to $n+\pi^-$.

Theoretically, quantities of this type cannot be deduced merely from "charge independence" because such invariance arguments presumably do not apply

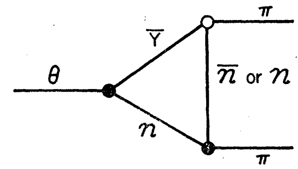

FIG. 1. Feynman diagram according to the "first assumption."

to the "weak" interactions. However, if one adopts the conventional field-theoretical concepts regarding elementary particles and elementary interactions, a simplifying assumption suggests itself, namely that only certain selected decay processes are truly elementary whereas the other ones would be indirect, or higher order, processes, involving the elementary transition as a virtual intermediate step. Obviously, any such assumption will correlate various lifetimes and branching ratios.

First assumption.—The Λ and Σ decays are elementary, whereas the θ decay, to lowest order, is described by Fig. 1.[2] (Y stands for Λ or Σ, and $\mathfrak{N}$ for nucleon.) According to this scheme, however, charged and neutral θ's would have roughly the same lifetime because in both cases the same matrix elements for the weak interactions (open circle in Fig. 1) are involved, and the strong interactions (black circles) are supposedly charge-independent. Experimentally, the two lifetimes ($\sim2\times10^{-10}$ sec for θ^0,[3] and $\sim10^{-8}$ sec for θ^+[4]) seem to differ by a factor of the order 100. It would be necessary to invoke a fortuitous cancellation by interference in the various charge channels of Fig. 1 (or some mechanism such as that proposed by Lee and Orear[5]) to explain the slow decay of θ^+. This cancellation would seem rather farfetched and unlikely.

Second assumption.—The θ decays are elementary, and the hyperon decays are indirect, as described by Fig. 2. The intermediate $\bar{\theta}$ can be either negative or

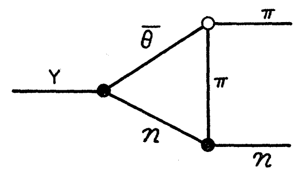

FIG. 2. Feynman diagram according to the "second assumption."

neutral; however, from the long life of the θ^+, we may conclude that the channels going through the neutral $\bar{\theta}$ strongly predominate (the matrix elements are about 10 times larger). In a rough approximation (accuracy $\sim20\%$) one can ignore the charged $\bar{\theta}$ channel. It is then