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Mean lifetimes for heavy mesons from cosmic rays have been reported by various groups using cloud chambers and Cerenkov counters.[1,2] We have carried out a measurement of the mean lifetime of artificially produced K^+ mesons by making use of their decay in flight in nuclear emulsion.

"Along the track" scanning of K^+ mesons in nuclear emulsions has shown a number of interactions in flight;[3] in addition, 19 events have been found in which there is a single outgoing track of grain density less than that of the incoming K meson. In each of these events the mass of the incoming particle was determined by grain counting and multiple-scattering measurements and its identity as a K^+ particle was thus established. If these events were due to interactions in flight, one would expect to find some stars with a lightly ionizing track coming out together with one or more black evaporation prongs. No such stars were observed. Also, none of the interactions in flight so far seen[3] gives off a visible L meson. It therefore seems reasonable to identify all events of this type as the decay of K^+ mesons in flight. From the number of decays in flight found and the proper-slowing-down time of all the K^+ mesons followed, a mean lifetime is obtained.

Stacks of stripped 600 μ Ilford G.5 nuclear emulsions were exposed edge on to the focused K^+-meson beam[4] of the Bevatron. The mesons were produced from a copper target at an angle of 90° to the 6.2-Bev proton beam and travel a distance of 2.7 m from the target to the emulsion stack. Exposures were made with two different momentum-acceptance bands, positive particles of 390 to 450 Mev/c momentum and 335 to 360 Mev/c momentum. In such an exposure the protons, K mesons, and π mesons, all of the same momentum, have different ranges in the emulsion stack, increasing in that order.

The scanning technique used is as follows. In the region of the plate just beyond where the protons stop, tracks are chosen on the basis of grain density. K-particle tracks have about twice the minimum grain density, while π mesons of the same momentum are essentially at minimum. Tracks between 1.8 and 3 times minimum grain density are picked and followed through the stack. Nearly all tracks selected in this way turn out to be K particles or τ mesons, except for a contamination of about 15% due to stray protons and π mesons scattered into the stack and prongs of stars formed in the emulsion. Excluding the track length due to τ^+ mesons, a total of 31.6 meters of K^+-meson track has been followed. The corresponding total proper-slowing-down time was calculated using the tables of Barkas and Young[5] and was found to be 19.2×10^{-8} sec. The mass of the K meson was taken as equal to that of the τ meson for this calculation. Since decays in flight near the end of a track may not be readily identified, the proper time spent in the last 2 mm before a stopping has not been included. From the 19 decays in flight observed we find a mean lifetime for K^+ mesons of

$$\bar{\tau}_{K^+} = 1.01 \begin{array}{l} +0.33 \\ -0.21 \end{array} \times 10^{-8} \text{ sec.}$$

The error given is the statistical standard deviation combined with a 10% uncertainty in the length of track scanned. If the decays in flight are due to K^+ mesons of two or more different mean lifetimes, the quantity that has been measured is an average of the form

$$\bar{\tau}_{K^+} = \left(\sum_i \frac{\alpha_i}{\tau_i} \right)^{-1} ,$$

where α_i is the fraction of the K^+ mesons entering the stack that is associated with a mean lifetime of τ_i. Owing to the time of flight from the target to the emulsion stack, less than 3% of any particles of mean life 0.3×10^{-8} sec or less would arrive at the emulsion stack. Any such short-lived particles would thus be highly discriminated against in this measurement. In the course of the experiment 1.7 meters of τ^+-meson track was followed which corresponds to a total proper slowing-down time of 1.07×10^{-8} sec. No decay in flight of a τ^+ meson was observed. The results of this experiment are consistent with those of Mezzetti and Keuffel[1] and Barker et al.[2]

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