Table I. Mass determinations from time of flight.

Run	Flight path (ft)	Time (mμsec)	$\pi^- - \pi^0$ mass (m_e)	π^- mass (m_e)
1	17.50 ± 0.01	130.79 ± 0.45		272.4 ± 1.1
2	12.44 ± 0.01	434.34 ± 0.79	8.984 ± 0.026	
3	17.50 ± 0.01	596.0 ± 1.1	8.998 ± 0.024	
Av(2, 3)			8.991 ± 0.020	
2 minus 3	5.055 ± 0.01	171.7 ± 1.4	9.05 ± 0.09	

shift the mean of the neutron distribution to longer times and also widen it. If the scattering is in the counter and not in the target, it will have little effect upon the value for the mass difference obtained from the difference measurement at two lengths. We have computed the scattering in the hydrogen target and found it to be negligible at these distances.

The standard deviation of the γ-ray peak is 3.5 mμsec; it is 4 to 6 mμsec for the fast neutron and 7 mμsec for the slow neutron. The size of the neutron widths is not completely understood at present and this uncertainty does not allow us to infer a meaningful limit for the π^0 lifetime.

The background in our neutron counter is currently limiting us in our ability to obtain more accurate measurements with longer flight paths. It appears to be due to three causes: radiation from the target, which decreases with solid angle and beam level; tube noise, which is constant but relatively small; and an effect that is of about constant value with depth. We are in the process of reducing the latter to allow us to increase the flight path by an appreciable factor.

We gratefully acknowledge the efforts of the many individuals who have assisted us in this experiment.

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* Work performed under the auspices of the U. S. Atomic Energy Commission.

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STRANGENESS 2 MESON

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(Received October 29, 1959)

In a previous communication[1] evidence was presented for a new strange particle. The interpretation of our event assigned to this particle a strangeness -2, a negative single charge, and a mass in the neighborhood of 700 Mev. According to the conventional scheme, a meson of strangeness 2 should occur as an isotopic singlet. The particle would have $Q=+1$ and $S=+2$; the antiparticle would have $Q=-1$ and $S=-2$. We shall call them D^+ and D^-, respectively. The event discovered[2] at Dubna, which motivated our search, may constitute evidence for the D^+, while ours suggests the existence of D^-.

We wish to report some interpretations of certain other anomalous events which seem to lend support to the D-particle hypothesis. First, there are the several anomalous decays of "K" mesons both at rest and in flight. An event has been reported[3] by a Columbia group, who saw a presumed K^+ decaying at rest into a 60-Mev π^+. They interpreted this as being a decay mode $K^+ \to \pi^+ + \pi^0 + \gamma$, and showed that 60 Mev is near the maximum of the expected π^+ spectrum. It happens, however, that a similar event has been found[4] at Bristol, and that the π^+ energy was the same in both cases to within the experimental error. The experiment enhances the possibility that the events are examples of the decay $D^+ \to \pi^+ + K^0$. Under this assumption, they give a D^+ mass of 719 ± 2 Mev.

There are perhaps three examples of D decay in flight. One is the Dubna event. The others were two anomalous events reported[5] from Duke. Both were produced by 2.7-Bev protons in the wall of a cloud chamber. The first showed a positive particle of momentum 500 ± 25 Mev/c which decayed into a positive secondary of momentum 87 ± 5 Mev/c. The kinematics of the decay preclude the possibility that the primary particle was a K meson. From its momentum and ionization alone, the mass of the particle was estimated to be between 590 and 840 Mev. If the charged secondary is taken as π^+, without regard to the nature of the neutral secondary, the primary mass is 800 ± 50 Mev; if the decay is taken as $D^+ \to \pi^+ + K^0$, and D^+ mass is 747_{-12}^{+8} Mev.

The interpretation of the other Duke event is more difficult. It appeared to its discoverers to require the presence of a negative particle of approximately 750-Mev rest mass, decaying into $K^0 + \pi^-$ with subsequent decay of the K^0 into $\pi^+ + \mu^- + \nu$. This interpretation fits the kinematics of the four charged tracks that were observed, but, if the D^- particle is really present, it is not clear how it can have been produced. The primary particle in this experiment was 1.9-Bev π^-, and the mode of production suggested by the authors was of the type $\pi^- + N \to D^- +$ hyperon. But this does not conserve strangeness, and we suggest instead that they saw $\pi^- + p \to D^+ + D^- + n$, which has a threshold of 1.9 Bev.

The D particle can also be invoked for an interpretation of two anomalous interactions[6] discovered in cosmic radiation by the Wisconsin group. In each of these events, a secondary particle came to rest in the emulsion and gave rise to a well-identified K meson of about 40-Mev kinetic energy. In one of the cases, an additional short prong was observed. If these events are regarded as interactions of D^- with bound neutrons according to $D^- + n \to K^- + \Lambda^0$, and if the target neutrons are taken to be at rest, the D mass in both cases is found to be about 730 Mev.

We wish finally to report that a careful reexamination of our event has failed to make any alternative interpretation more plausible than it was at the time of our earlier Letter. In particular, one of us has made a careful study of the possibility that prong 6 of our event is a He^3 or He^4 nucleus initiating a reaction in a nucleus of the emulsion. The charged secondaries leaving the end of this track appear to be so oriented that momentum can only be conserved if at least one neutral particle accompanies them. The proton coming from the star has an energy of 3.6 Mev, and the upper limit of the energy of the incoming particle is known to be low. The only nuclear interaction which might fit these facts is $N^{15}(He^3, pn)O^{16}$ with a Q of 4.4 Mev. Analyzing the kinematics for this reaction, and taking into account only the directions of the He^3 and O^{16} momenta together with the known momentum of the proton, we find that the angle between the incident track and the resultant momentum of charged secondaries cannot exceed 35 degrees. On the other hand, the corresponding observed angle cannot be less than about 60 degrees, unless one or more of the charged particles scatters within such a small distance from the star that we cannot observe it. In view of these conclusions, and of the fact that the kinematics of the star are perfectly consistent with

Table I. Summary of possible D-meson events.

Laboratory	Present interpretation	No. events	D mass (Mev)
Columbia (em.)	$D^+ \to \pi^+ + K^0$ (rest)	1	719 ± 2
Bristol (em.)	$D^+ \to \pi^+ + K^0$ (rest)	1	719 ± 2
Dubna (b. ch.)	$D^+ \to \pi^+ + K^0$ (flight)	1	750 ± 200
Duke (d. cl. ch.)	$D^+ \to \pi^+ + K^0$ (flight)	1	747_{-12}^{+8}
Duke (d. cl. ch.)	$D^- \to \pi^- + K^0$ (flight)	1	750
Rochester (em.)	$D^- +$ nucleus $\to \Sigma^+ + \Lambda^0$	1	640_{-100}^{+120}
Wisconsin (em.)	$D^- + n \to K^- + \Lambda^0$	2	730

well-known[7] hyperfragment mesonic decays, we feel that our earlier arguments for the interpretation of this prong as a hyperfragment have not been weakened.

Table I summarizes the present evidence for the *D* particle. We feel that, despite the ambiguities of the interpretation in some cases, the situation is now such that the existence of the particle cannot easily be discounted. We are therefore hoping to undertake a systematic search for the particle in a mass-separated beam from nucleon-nucleon bombardment. The early events, together with a knowledge of the mass and possible decay modes of the particle, suggest that its lifetime is comparable with that of the charged *K*. Its existence can therefore be confirmed by conventional techniques. If the search is successful, a direct confirmation of the properties of the particle should be attempted with a characteristic reaction such as $K^+ + p \to D^+ + \Sigma^+$.

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