A POSSIBLE NEUTRAL CASCADE MESON DECAY

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An examination of 20000 photographs obtained by irradiating a xenon bubble chamber by a beam of 3-Bev/c negative π mesons revealed an event which can be interpreted as a decay of a heavy neutral meson according to the scheme

$$D^0 \to K^+ + \pi^- + Q.$$

The mass of this particle computed on the basis of the K^+ and π^- meson momenta was found to be $m_{D^0} = (660 \pm 50)$ Mev.

WANG Kang-chang and co-workers[1] and Sinha and Sengupta[2] observed during an investigation of cosmic radiation several events which were interpreted by the authors as the decay of a neutral particle according to the scheme

$$D^0 \to K^+ + \pi^- + Q, \quad (1)$$

where Q = 10 — 50 Mev. In this connection, an experiment involving high-energy accelerators to search for particles with analogous decay schemes would be of interest.

An examination of 20000 photographs obtained by irradiating the two-liter xenon bubble chamber of the Institute of Theoretical and Experimental Physics of the U.S.S.R. Academy of Sciences[3] in a beam of 3 Bev/c negative π mesons disclosed the

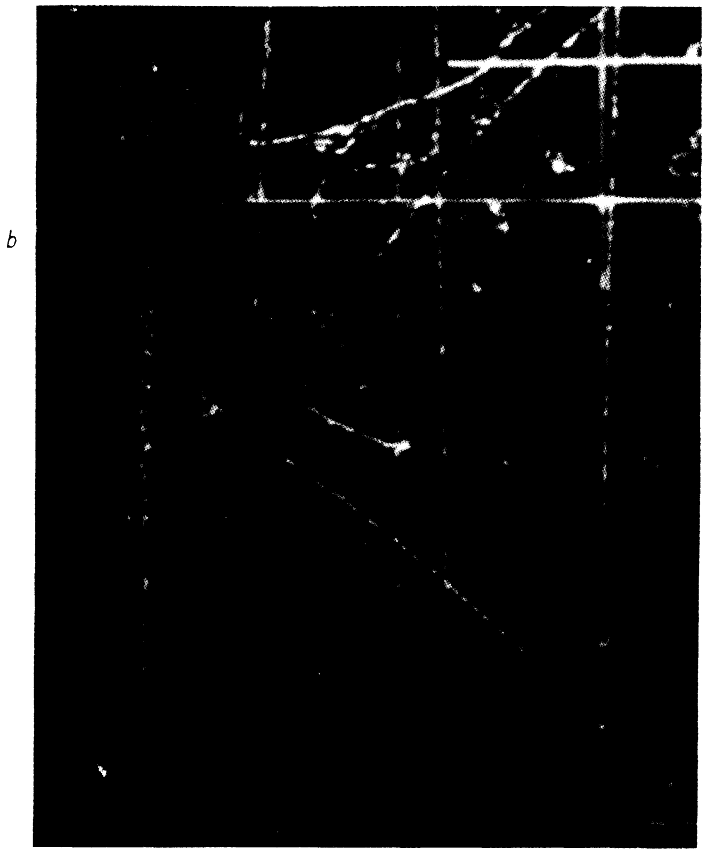

FIG. 1. Suggested decay of a heavy meson by the scheme $D^0 \to K^+ + \pi^-$. The point of decay is denoted by the letter b.

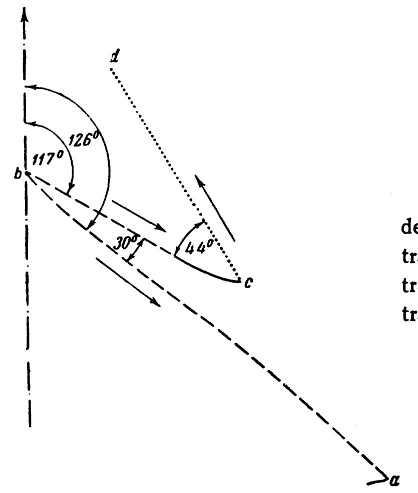

FIG. 2. Diagram of decay: bc – K^+-meson track; cd – $\pi^+(\mu^+)$-meson track; ba – π^--meson track.

event shown in Fig. 1. The geometrical diagram is shown in Fig. 2. The direction of the primary beam is shown by the dash-dot arrow. Points a, b, c lie in the working volume. Track cd escapes into the glass.

The chamber was operated without a magnetic field. The identification of the particles was made by means of ionization and multiple scattering. The data of the measurements are given in the table. The errors shown in the table are statistical.

The mean values of $p\beta$ along the track were measured by the multiple-scattering method. The momentum p of the particle with track bc (henceforth referred to as particle "bc" etc.) was determined from its range, the remaining momenta were calculated from the $p\beta$ values.

The mass of particle "bc" was determined from the multiple scattering – residual range relation, the mass of particle "ba" was determined from the ionization – multiple scattering relation. The values of the ionization shown in the table were measured by the "porosity" method (by the ratio of the total gap length to the total track length).[4] Track cd was used for calibration (the value of the ionization along track cd was taken as equal to 1.46, i.e. equal to the ionization of a π^+ meson from a K_{π_2} decay). The calculated values of the ionization were computed from the momentum values p.

The ionization and multiple scattering measurements indicate that the particles move in the directions shown by the arrows in Fig. 2. The mass of particle "bc", which stops in the chamber, turned out to be (490 ± 190) Mev, i.e., coinciding, within the limits of statistical error, with the mass of a K meson. Measurement of the quantity $p\beta$ for particle "cd" by the multiple scattering method gave the value (180 ± 54) Mev/c, in good agreement with the values for K_{π_2} or K_{μ_2} decays. We note that for a μ^+ meson from a K_{μ_2} decay $p\beta$ = 216 Mev/c, for a π^+ meson from a K_{π_2} decay $p\beta$ = 170 mev/c, while the maximum value of $p\beta$ for an electron from a $\mu - e$ decay is 53 Mev/c (the mean value of $p\beta$ for a $\mu - e$ decay[5] is $p\beta$ = 38 Mev/c). Thus both the measurement of the mass along track bc and the measurement of $p\beta$ for track cd is evidence of the fact that the sequence "bc" – "cd" is the decay of a K^+ meson, and not a $\pi - \mu - e$ decay. The ionization of tracks bc and cd does not contradict this conclusion.

Particle "ba" experiences in the chamber a nuclear interaction, giving at point a a small star of the evaporation type. The value of $p\beta$ for this particle, measured by the multiple scattering method, is equal to (113 ± 22) Mev/c. The mass of particle "ba" determined from the ionization – multiple scattering relation proved to be (195 ± 55) Mev, i.e. close to the mass of a π or μ meson. Since particle "ba" gives a nuclear interaction at the end of its range, it may be assumed that it is a π meson.

The measurements and the results of the calculations show that the given case cannot be interpreted as the production of a π^+ meson in a star caused by a neutron at point a with a subsequent scattering at point b and a $\pi - \mu - e$ decay at point c, nor the production of a K^+ meson in the same star with scattering at point b and a K_{μ_2} decay at point c.

The event described can likewise not be interpreted as a star produced by a neutron at point b, in which two strange particles and a π meson are produced (the reaction $n + n \rightarrow \Lambda^0 + K^+ + \pi^- + n$), since the calculations indicate that the threshold for such a reaction is approximately 0.9 Bev above the maximum energy of neutrons which can be produced in the chamber under the given conditions of irradiation. The high threshold is associated

Track	Particle	Range, (g/cm²)	pβ,(Mev/c)	Momentum, (Mev/c)	Mass, (Mev)	Ionization	
						exp	calc
bc	K^+	6.4	—	225±20	490±190	5.0±1.4	5.7
cd	$\pi^+(\mu^+)$	>11.06	180±54	214±65	—	(1,46)	1.44
ba	π^-	14.5	113±22	172±35	19±555	2.4±0.4	1.8

with the fact that K^+ and π^- mesons in the laboratory system travel backwards with respect to the direction of the primary beam, while in the center-of-mass system of the colliding particles they should have a very high kinetic energy.

The event may be interpreted as the result of the reaction $K^0 + n \rightarrow n + K^+ + \pi^-$. However, interactions of K mesons with Xe nuclei in which π mesons are produced usually lead to multi-pronged stars. Therefore it seems to us more probable to interpret the given case as the decay of a neutral particle according to the scheme (1). The mass of this particle calculated from the momenta of the $K^\pm$ and π^- mesons and from their angle of divergence proves to be equal to

$$m_{D^0} = (660 \pm 50)\ \text{Mev}.$$

An attempt was also made to compute the mass of the D^0-meson from the kinematics of its production under the assumption that it is produced in the reaction

$$\pi^- + p \rightarrow n + D^0. \quad (2)$$

If the calculation is made under the assumption that the D^0-meson is produced in a collision of a π^- meson with a proton at rest, then the value of the mass of the D^0 meson is found to be equal to 440 Mev. If one also takes into account the Fermi motion of the nucleons in the nucleus and assumes, for example, that the π meson collides with a proton moving towards it with a kinetic energy of 10 Mev (momentum 170 Mev/c), then the mass of the D^0 is found to equal 660 Mev. We see that the determination of the mass from the kinematics of reaction (2) has a very large error owing to the motion of the nucleons in the nucleus, but, nevertheless, this does not conflict with the possibility of the reaction taking place. The same is true for the reaction

$$\pi^- + p \rightarrow \Xi^0 + D^0. \quad (3)$$

Bearing in mind the above possibility, and also the communication about the D^+ meson[6] of mass $m_{D^+} = (742 \pm 25)$ Mev, one may apparently speak about the existence of three particles: the D^+, D^0, and D^- mesons with close values of mass and the same decay schemes of the type

$$D \rightarrow K + \pi.$$

The question of the place of the D^0-meson in the system of elementary particles and the consequences that result from its existence are discussed in reference 7.

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Translated by E. Marquit
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