ON THE D MESON

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The processes most favorable for the production of D mesons are discussed. Experiments for the determination of the spin and the parity of the D meson are proposed.

1. Many of the existing classifications of elementary particles contain a free place. The scheme of Gell-Mann and Nischijima[1,2] leaves room for a meson with strangeness 2 and isotopic spin 0. The scheme of Salam and Polkinghorne[3] has a free spot for a τ particle, if we regard the τ and the θ as identical. In Sakata's model of elementary particles[4] one can construct the particles

$$D^+ = \frac{1}{\sqrt{2}}(pn - np)\,\bar{\Lambda}\bar{\Lambda}, \quad D^- = \frac{1}{\sqrt{2}}(\bar{p}\bar{n} - \bar{n}\bar{p})\,\Lambda\Lambda. \quad (1)$$

In the Markov scheme[5] the analogous particle is represented by ($N\bar{\Xi}$).

On the other hand, evidence was recently found in the propane bubble chamber at Dubna for the existence of a heavy meson with mass ~ 750 Mev,[6] which decays according to the scheme

$$D^+ \to K^0 + \pi^+. \quad (2)$$

It is of interest in this connection to investigate which reactions are the most appropriate for the further detection of the D meson and also which processes are most convenient for the study of the properties of this meson.

2. The D meson can be produced in the reaction

$$\pi + N \to D + 2K + N \quad (3)$$

or in the reactions

$$K + N \to D + K + N, \quad (4)$$

$$K + N \to D + \text{hyperon}, \quad (5)$$

and also through annihilation of a nucleon with an antinucleon:

$$N + \bar{N} \to D^+ + D^-. \quad (6)$$

We give the ratios of the probabilities of these reactions, calculated with the help of the statistical theory of the multiple production of particles (for the method of calculation see references 8 and 9):

$$\frac{\sigma(\pi^- + N \to D + 2K + N)}{\sigma(\pi^- + N \to \Xi + 2K)} \sim 3.2 \cdot 10^{-2}, \quad p_{\pi^-} = 7\ \text{Bev/c},$$

$$\frac{\sigma(K^+ + N \to D + K + N)}{\sigma(K^+ + N \to \pi + K + N)} \sim 3.3 \cdot 10^{-4}, \quad p_{K^+} = 2\ \text{Bev/c},$$

$$\frac{\sigma(K^+ + N \to D^+ + \Lambda)}{\sigma(K^+ + N \to K + N)} \sim 0.18, \quad p_{K^+} = 2\ \text{Bev/c},$$

$$\frac{\sigma(N + \bar{N} \to D^+ + D^-)}{\sigma(N + \bar{N} \to K^+ + K^-)} \sim 0.3, \quad p_{\bar{N}} = 0.$$

All momenta are given in the laboratory system of coordinates.

In the calculation we set $M_D/M_N = 0.8$ and assumed that the π mesons and baryons are produced in a volume V_π with radius $r_\pi = \hbar/m_\pi c = 1.4 \times 10^{-13}$ cm, while the K mesons and the D meson are produced in a smaller volume V_K with radius $r_K = \hbar/m_K c = 0.4 \times 10^{-13}$ cm. If the experimental values of the last two ratios turn out to be smaller than the calculated ones, this may indicate that the D mesons are produced in a volume which is smaller than the corresponding volume for the K mesons.

The above-mentioned calculations show that the use of a K^+ meson beam is most convenient for the detection of the D meson.

It should be noted that the scheme of Salam and Polkinghorne also admits of the existence of the D^0 meson. One may expect that the D^0 meson decays according to the schemes

$$D^0 \to \pi^0 + K^0, \quad D^0 \to \pi^+ + K^-, \quad D^0 \to \pi^- + K^+,$$

s_D	Π_D	A	B
1	0	−1	0
0	−1	0	1
2 3	−1 −1	2/5	−1/5
0 1 2	1 −1 1	>0 (≠2/5)	≠ −1/5

and its mass will be close to the masses of the D^+ and D^- mesons. In the scheme of Gell-Mann and Nischijima this D^0 meson can be identified with the ρ_0 meson, whose existence has been the subject of wide discussion in recent times.

3. Information on the spin of the D meson can be obtained by measuring the angular correlation in the cascade process

$$K + N \rightarrow D + \text{hyperon}, \quad D \rightarrow K + \pi. \tag{7}$$

However, this correlation gives two possible integer values i and i+1 [for example, (0,1) or (1,2)] for the spin of the D meson, leaving the choice open.

If the reaction

$$D^- + He^4 \rightarrow {}_{\Lambda}He^4 + K^- \tag{8}$$

occurs and the angular distribution of He^4 and K^- is isotropic, one may conclude that the D^- meson is a pseudoscalar (since the relative parity of Λ and K is odd).[11] In the case of a nonisotropic distribution the spin and the parity of the D^- meson cannot be determined uniquely from the data of this experiment.

More definite information on the spin and the parity of the D meson may be obtained from the study of the capture of the D^- meson by the deuteron:

$$D^- + \text{deuteron} \rightarrow \Lambda^0 + \Lambda^0 \rightarrow 2p + 2\pi^-. \tag{9}$$

One should expect that the D^- will be captured by the deuteron predominatly in the S state.[12] Then the angular correlation of the decay products of the two Λ hyperons is equal to[13]

$$1 + \alpha^2 (A\, \mathbf{n}_1\mathbf{n}_2 + B(\mathbf{n}_1\mathbf{n})(\mathbf{n}_2\mathbf{n})),$$

where α is the asymmetry coefficient of the Λ decay; $\mathbf{n}_1$ and $\mathbf{n}_2$ are unit vectors in the direction of the momenta of the decay products, referred to the rest systems of the first and second Λ hyperons, respectively; $\mathbf{n}$ is a unit vector in the direction of the line connecting the two Λ hyperons. The values of A and B, which depend on the spin S_D and the parity Π_D of the D^- meson, are given in the table.*

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*After this paper had been written, it became known to the author that after the Kiev Conference seven more cases have been found which can be interpreted as decays and reactions of D^+ mesons.[14]