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ON THE D- MESON

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* After this note was written the author learned that other seven events which can be interpreted as the decays and reactions of the D -mesons have been found.

SUMMARY

Processes most favorable for the production of the mesons are discussed. Experiments are proposed to determine the spin and parity of the D -meson.

I.

1. Recently the propane bubble chamber workers of Dubna found/1/ that there may exist a heavy meson (throughout this paper we will call it D meson) with mass 750 MeV and decays into

$$D^{+} \longrightarrow K^{0} + \pi^{+}. \qquad (1)$$

On the other hand, in many systematics of elementary particles, there are rooms for the D meson. According to the Gell-Mann-Nishijima system/2/,/3/ there exists an isosinglet meson with strangeness 2. In the Salam-Polkinghorne system/4/, if the τ and θ are considered as identical, the room originally assigned to τ meson ($T = 0$, $\mu = 1$), can now be assigned to the D meson. In the Sakata model of elementary particles/5/, the D meson is represented as follows:

$$\begin{cases} D^{+} = \frac{1}{\sqrt{2}}(pn - np)\tilde{\Lambda}\tilde{\Lambda} \\ D^{-} = \frac{1}{\sqrt{2}}(\tilde{p}\tilde{n} - \tilde{n}\tilde{p})\Lambda\Lambda \end{cases} \qquad (2)$$

in the Markov model of elementary particles the D^{+} meson is represented by $(N\tilde{\Xi})$/6/.

It is interesting to discuss what processes are most favorable for the production of the D -mesons, if they do exist, and what experiments may give useful information on the properties of the D -mesons.

II.

2. Experimentally, the D -meson can be produced in the π-meson-nucleon reaction:

$$\pi + \text{nucleon} \longrightarrow D + 2K + \text{nucleon} \qquad (3)$$

or through the K-meson-nucleon reaction:

$$K + \text{nucleon} \longrightarrow D + K + \text{nucleon} \qquad (4)$$

$$\longrightarrow D + \text{hyperon} \qquad (5)$$

or through the nucleon-antinucleon annihilation:

$$\text{nucleon} + \text{antinucleon} \longrightarrow D^{+} + D^{-} \qquad (6)$$

The ratios of the cross sections of these processes to those of same other processes are calculated by using the statistical theory of multiple production and tabulated in Table 1. In the calculation, M_D / M_N is taken to be 0.8 and it is assumed that the D meson as well as K meson are produced in a smaller volume in comparison with those relating to the production of D meson and baryons/7/. The methods of calculation are referred to/8/,/9/. It can be seen from Table 1 that it is most favorable to produce the D-meson by using a K^+ - beam.

If the D^+-meson, the possibility of its existence was discovered by the Dubna group, is taken to be the θ particle in the Salam-Polkinghorne scheme, then it is expected there exist further new mesons, namely: D^- and D^0, which decay into

$$D^- \longrightarrow \pi^- + \tilde{K}^0 \qquad (7)$$
$$\longrightarrow \pi^0 + K^-$$

and

$$D \longrightarrow \pi^+ + K^-$$
$$\longrightarrow \pi^- + K^+ \qquad (8)$$
$$\longrightarrow \pi^0 + K^0$$

However, we prefer to identify the D^0 with the ρ_0 meson (strangeness = 0) in the Gell-Mann-Nishijima scheme, which was discussed with great interest recently.

3. The information on the spin of the D meson may be obtained by measuring the angular correlation of the a cascade process:

$$K + \text{nucleon} \longrightarrow D + \text{hyperon} \qquad (9)$$
$$\hookrightarrow K + \pi$$

But this can only limit the spin of the D meson to i and i + 1/10/, here i is as integer determined by the experiment. (For instance, /0.1/, /1.2/ etc.). Such measurement can not fix the value of the spin uniquely.

If the following reaction

$$D^- + He^4 \longrightarrow {}_\Lambda He + K^- \qquad (10)$$

exists, and if the final state is isotropic, then one can conclude that the D meson is a pseudoscalar meson (since Λ and K have negative relative parity/11/). But if anisotropy appears in the final state, the spin and parity of D meson can not be determined uniquely.

From the following capture reaction

$$D^- + \text{deuteron} \longrightarrow \Lambda^0 + \Lambda^0 \qquad (11)$$
$$\hookrightarrow p + \pi^- \quad \hookrightarrow p + \pi^-$$

more conclusive information about the spin and parity of the D-meson can be obtained. Since the capture process occured mainly through S state /12/, the decay products of the hyperons have the following angular correlation

$$1+\alpha^2\left(A\vec{n}_1\cdot\vec{n}_2+B\vec{n}_1\cdot\vec{n}\,\vec{n}_2\cdot\vec{n}\right) \qquad (12)$$

where α is the asymmetry parameter of the Λ decay. $\vec{n}_1$, $\vec{n}_2$ are respectively the unit vectors along the line of flight of the decay products measured in the rest system of the first and the second Λ hyperons. $\vec{n}$ is the unit vector along the line joining the two Λ particles. The value of A and B can be used to determine the spin and parity of the D meson, they are tabulated in Table 2.

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Table 1

(The momentum are given in the lab.system)

$\dfrac{\sigma(\pi^- + N \to D + 2K + N)}{\sigma(\pi^- + N \to \Xi + 2K)}$	$\sim 3{,}2 \times 10^{-2}$,	$P_{\pi^-} = 7\ BeV/c$
$\dfrac{\sigma(K^+ + N \to D + K + N)}{\sigma(K^+ + N \to \pi + K + N)}$	$\sim 3{,}3 \times 10^{-4}$,	$P_{K^+} = 2\ BeV/c$
$\dfrac{\sigma(K^+ + N \to D^+ + \Lambda)}{\sigma\,(K^+ + N) \to K + N)}$	$\sim 0{,}18$ *),	$P_{K^+} = 2\ BeV/c$
$\dfrac{\sigma(N + \tilde{N} \to D^+ + D^-)}{\sigma(N + \tilde{N} \to K^+ + K^-)}$	$\sim 0{,}3$ *),	$P_{\tilde{N}} = 0$

* If the ratios tabulated here turn out to be much larger then those obtained experimentally, it can be concluded that the D meson is produced in volume V_D, which is smaller than V_K.

Table 2.

Spin (D)	Π_D	A	B
1	0	-1	0
0	-1	0	1
$\begin{cases}2\\3\end{cases}$	$\begin{cases}-1\\-1\end{cases}$	$\frac{2}{5}$	$-\frac{1}{5}$
$\begin{cases}0\\1\\2\end{cases}$	$\begin{cases}1\\-1\\1\end{cases}$	$>0\ (\neq \frac{2}{5})$	$\neq -\frac{1}{5}$

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