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AN ANALYSIS OF 'ANOMALOUS' COSMIC RAY V^0-EVENTS IN VIEW OF A POSSIBLE EXISTENCE OF A NEUTRAL D-MESON

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If there exist charged D mesons [1,2] with the decay scheme

$$D^{\pm} \rightarrow K + \pi + Q \quad (\approx 110 \text{ MeV}), \qquad (1)$$

then it is naturally to suppose the existence of a neutral particle with the same decay mode. A possibility of a D^0-meson existence has been discussed in [3], as well as in [4].

In this connection it would be interesting to analyse the so-called 'anomalous' V^0– events found in cosmic rays and reported earlier, the more as there is information[5,6] on the neutral particles with the decay schemes

$$V^0 \rightarrow K^+ + \pi^- + Q \quad (\approx 10 \div 50 \text{ MeV}). \qquad (2)$$

From the papers[7–17] published during 1952–1957, we have chosen 'anomalous' V^0– decays which could not be identified either as Λ^0, or as Θ^0. In selecting the events, we neglect such V^0 which have the value for Q different by not more than two standard errors from those known for Λ^0 and Θ^0 and have the values for the transverse momentum of more than 160 MeV/c, that corresponds to the decay mode (2), but with $Q > 110$ MeV. Of all the 'anomalous' V^0– events published 40 satisfied these requirements. Under the assumption of the two–particle decay scheme $V^0 \rightarrow K + \pi + Q$, the data on these 40 events are presented in Fig. 1 in terms of the transverse momentum $P_\perp$ and the parameter

$$\alpha = \frac{P_K^2 - P_\pi^2}{P_0^2}, \qquad (3)$$

where P_K is the K-meson momentum, P_π is the π -meson momentum, whereas P_0 is the total momentum of these particles. For the parameter α, the value (3) was taken since the decays ($K^+\pi^-$) and ($K^-\pi^+$) have the properties, mirror–symmetrical with respect to $\alpha = 0$, and the representation of the data in one graph increases the statistics. The figures near the points denote the values of $Q(K\pi)$ for given V^0– events. The maximum likelihood function $L(Q)$ for $Q(K\pi)$ -value for these events is shown in Fig. 2. The most probable value of $Q(K\pi)$ was found to be 38.5MeV. In this connection an attempt was made to analyse the data of Fig. 1 in terms of the only two-particle decay scheme

$$D^0 \rightarrow K + \pi + Q \quad (\approx 38.5 \text{ MeV}). \qquad (4)$$

It turned out that this decay scheme is consistent with the data for which the Q-value is in the range 20–50 MeV. At the same time the data on the events with a Q -values more than 50 MeV proved to be very different from the properties following from the above scheme, this difference considerably exceeding the accuracy of the published characteristics of the V^0-decays belonging to this group.

Therefore, we have to state that it seems impossible to interpreat all the 'anomalous' events as the decays by the only mode (4).

An analysis of the data in Fig.1 shows that the points with $Q < 50$ MeV are grouping below the solid line, while those with $Q > 50$ MeV above this line. This points out a possible existence of two types of the decay mode $D^o_i \to K + \pi + Q_i$ (with $Q_1 < 50$ MeV and $Q_2 > 50$ MeV).

The maximum likelihood functions for Q-values in these two groups of V^o- events are given in Figs. 3 and 4 . The values of $Q_1 = 35.5 \pm 2.0$ MeV and $Q_2 = 67.8 \pm 2.0$ MeV have been obtained for the most probable decay energies, in each group.

To proceed with the analysis of a possible existence of two types of neutral particles having the decay schemes like those of a D^o-meson, there were constructed ($P_\perp, \alpha, Q$)-representations under the assumptions that there are either only $Q_1 = 35.5$ MeV or only $Q_2 = 67.8$ MeV. This has shown that the experimental points with 20 MeV $< Q <$ 50 MeV fit the decay with $Q_1 = 35.5$ MeV, and do not fit the decay with $Q_2 = 67.8$ MeV. On the contrary, the points with 50 MeV $< Q <$ 75 MeV are in good agreement with the decay in which $Q_2 = 67.8$ MeV and are in disagreement with the decay in which $Q_1 = 35.5$ MeV.

The final data are given in Figs. 5 and 6 in terms of $P_\perp, \alpha' = \beta(\alpha - \alpha^*) + \alpha^*$ and $Q(K\pi)$ where $\alpha^* = \frac{m_K^2 - m_\pi^2}{M^2_{D^o}}$. As is seen, 13 'anomalous' V^o-decays satisfy well the two-particle decay scheme

$$D^o_1 \to K + \pi + Q \qquad (= 35.5 \pm 2.0 \text{ MeV}).$$

7 out of 13 decays follow the mode $K^+ + \pi^-$ and 6 the mode $K^- + \pi^+$. 15 decays satisfy the two-particle decay scheme

$$D^o_2 \to K + \pi + Q \qquad (= 67.8 \pm 2.0 \text{ MeV}).$$

8 of them decayed by the scheme $K^+ + \pi^-$ and 7 - by the scheme $K^- + \pi^+$.

The yield of such two-particle decays in cosmic rays may be estimated as being of the order of 1% of the known neutral unstable particles. The possibility of accounting for a certain (and appreciable) number of 'anomalous' V^o events by the two-particle decays of two neutral particles with different masses seems to some extent surprising. Therefore, to make the above circumstance more clear, it is necessary to analyse the 'anomalous' V^o -particles obtained by means of bubble chambers exposed to the beams from large accelerators. First of all, it is interesting to know the mechanism of their production from which it is possible to obtain their properties and to find their place in the systematics of elementary particles available now.

So, for instance, it is possible that there exist pairs of particles D^+, D^o of strangeness $+2$ and their antiparticles D^-, $\bar{D}^o$ of strangeness -2. In this case D^o -particles would have been observed in the reactions of the type

$$\pi^- + p \to \Xi^o + D^o.$$

The yield of D^o -particles in cosmic rays is about the same as that of Ξ -hyperons. This possibility, however, leads to some important consequences.

As is well-known this scheme if followed consistently, /18/ points out that there must exist two-charged particles D^{++} and D^{--}, which have not yet been observed. Besides, the existence of some more hyperons is required which have not yet been observed either.

In the light of this it would have been appropriate to consider the possibility when D^o-particles are not 'true' particles, but represent the bound systems of the KK or $K\overline{K}$ type/19/. For example, among the systems of $K^o \overline{K^o}$ and K^+K^- types the latter is, evidently, lighter than the former because of the additional electromagnetic interaction.

As for the outward appearance, these systems will be alike the neutral particles with zero strangeness and will be generated in the reactions

$$\pi^- + p \rightarrow n + D^o$$
$$K^- + p \rightarrow \Lambda^o + D^o$$

The first of these reactions is convenient to be observed below the production threshold for $K\overline{K}$-meson pairs, i.e., in the range of the kinetic meson energies up to 1.34 BeV.

In conclusion it would be worth while to note that Q_1 is close to the $\Lambda^o \rightarrow N + \pi$ decay energy, whereas Q_2 – to the decay energy of $\Xi \rightarrow \Lambda^o + \pi$. In this connection it is interesting to remind of some regularities in the behaviour of the masses of elementary particles/20/.

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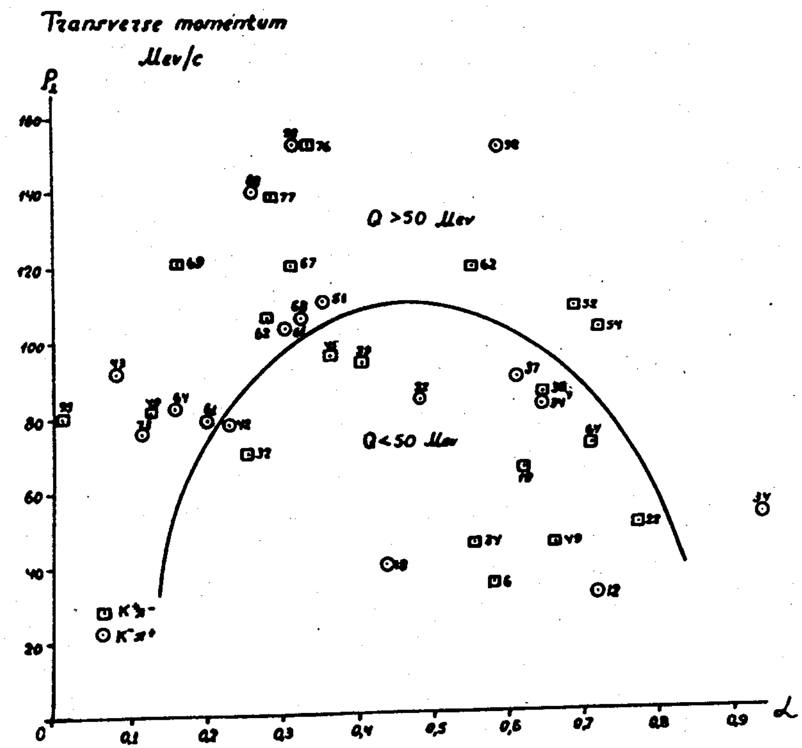
Transverse momentum
Mev/c
$p_\perp$
Q >50 Mev
Q<50 Mev
$K^+\pi^-$
$K^-\pi^+$
α

Fig. 1.

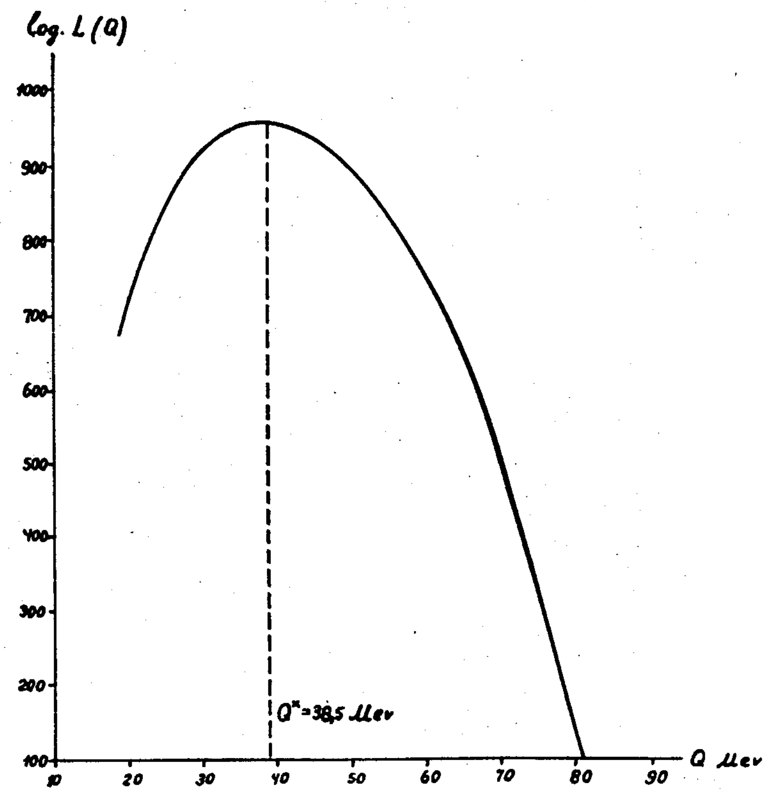
log. L (Q)
$Q^* = 38,5$ Mev
Q Mev

Fig. 2

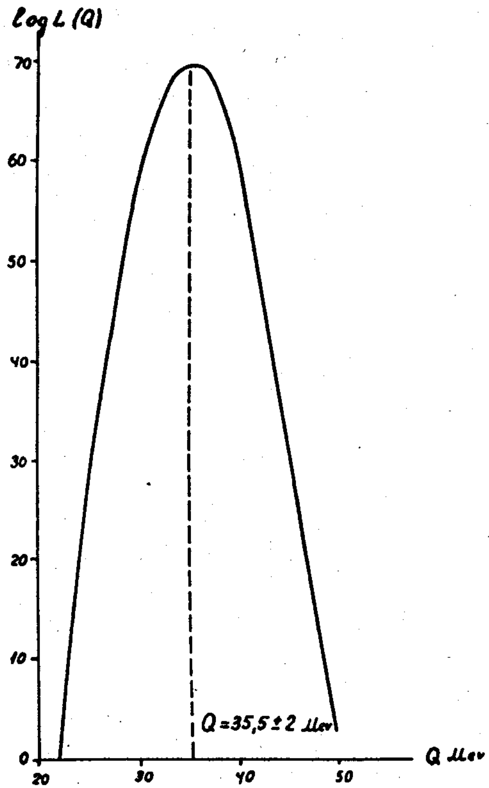
log L (Q)
70
60
50
40
30
20
10
0
20
30
40
50
Q Mev
Q = 35,5 ± 2 Mev

Fig. 3

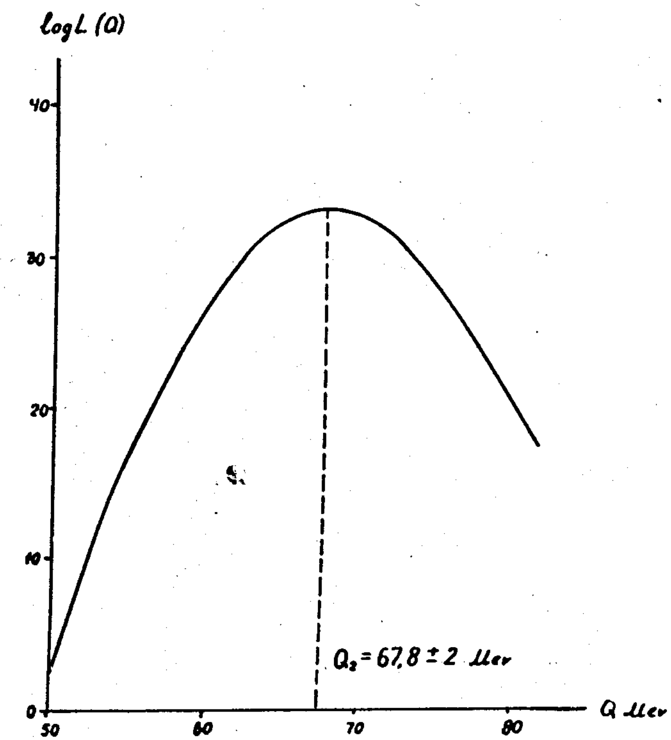
log L (Q)
40
30
20
10
0
50
60
70
80
Q Mev
Q₂ = 67,8 ± 2 Mev

Fig. 4

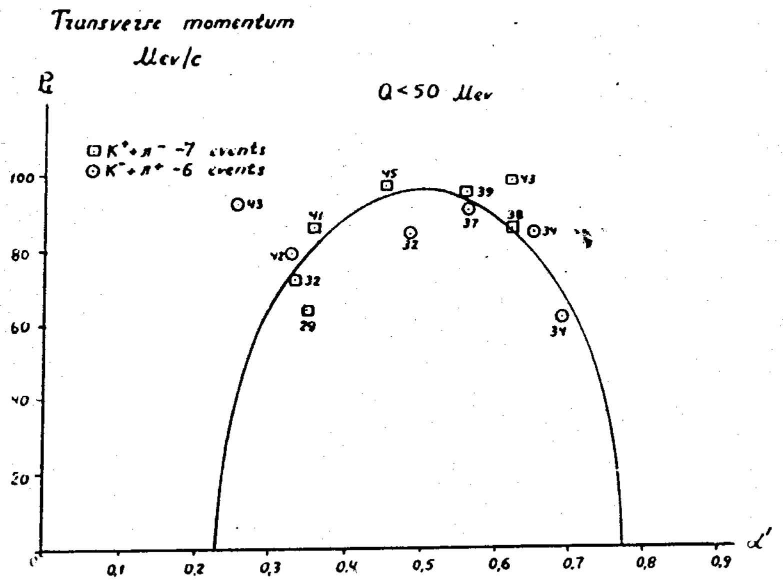
Transverse momentum
Mev/c
Q<50 Mev
⊡ $K^+ + \pi^-$ -7 events
⊙ $K^- + \pi^+$ -6 events
$P_\perp$
α'

Fig. 5

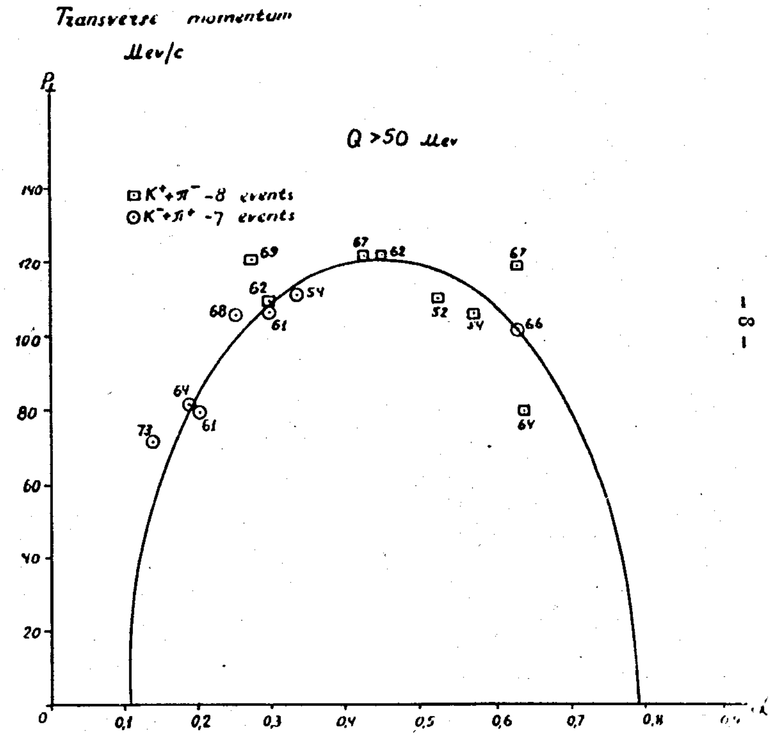
Transverse momentum
Mev/c
Q>50 Mev
⊡ $K^+ + \pi^-$ -8 events
⊙ $K^- + \pi^+$ -7 events
$P_\perp$
α'

Fig 6

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