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ON THE POSSIBLE EXISTENCE OF A NEW K' MESON

by
J. Tiomno, A. L. L. Videira, and N. Zagury

CENTRO BRASILEIRO DE PESQUISAS FÍSICAS
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ON THE POSSIBLE EXISTENCE OF A NEW K' MESON [*,1]

J. Tiomno, A. L. L. Videira and N. Zagury
Centro Brasileiro de Pesquisas Físicas
and
Faculdade Nacional de Filosofia
Rio de Janeiro, E. G., Brazil

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It has been experimentally established that the Λ particles produced in the reaction

$$p + \pi_- \longrightarrow K_o + \Lambda \tag{1}$$

are strongly peaked backward in the C. M. system.

Pais [2] has tried to explain this result by assuming the existence of a $KK\pi$ interaction and that the main contribution to

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reaction (1) comes from the Feynman graph of Fig. 1, assuming $\varkappa_+$ to be a K_+ meson. He has obtained a reasonable qualitative agreement with the available experimental data at 1.1 Bev. However his scheme, supposing opposite parities for K_+, K_o leads to many problems of difficult solution, arising from the failure of charge independence of the π-interaction. One such difficulty results from the lack of a $KK\pi_o$ interaction, which gives rise to a mass of charged π's smaller than that of π_o [3].

In the present paper we shall try, mantaining the convenient features of Pais scheme, to overcome such difficulties by assuming the existence of another K' meson of the same hypercharge and isospin (1/2) of the ordinary K-meson but of opposite parity [4].

Reaction (1) proceeds now mainly via the same graph as in Fig. 1 but the intermediate $\varkappa_+$ being a K'_+-meson instead of K_+ .

In order to compute the differential cross-sections of reaction (1) we add to the usual D'Espagnat-Prentki interaction Hamiltonian density a $KK'\pi$ and a $\Lambda K'N$ term:

$$2\, m_K\, f\, (\overline{K}\, \vec{\tau}\, K' + \overline{K}'\, \vec{\tau}\, K)\, .\, \vec{\pi} + g\, (\overline{K}'\, \overline{\Lambda}\, \Gamma\, N + \text{h.c.}) \qquad (2)$$

where m_K is the mass of the K-meson and Γ is 1 or γ_5 according to the parity of K'.

Using Born approximation we get for the differential cross section:

$$\frac{d\sigma}{d\Omega} = A\, \frac{1 + v_p\, v_\Lambda\, \cos\theta \pm m_\Lambda\, m_p/E_p\, E_\Lambda}{\left[m_\pi^2 + m_K^2 - \mu^2 - 2E_\pi\, E_K(1 + v_\pi\, v_K\, \cos\theta)\right]^2} \qquad (3a)$$

$$A = 4\, m_K^2 \left(f^2/_{4\pi}\right)\left(g^2/_{4\pi}\right) \frac{p_K\, E_p\, E_\Lambda}{p\pi\, (E_p + E_\pi)^2} \qquad (3b)$$

where μ is the mass of the K'-meson and θ the angle between π and Λ in the C. M. system. The plus sign corresponds to $\Gamma = 1$ (K' scalar), and the minus to $\Gamma = \gamma_5$ (K' pseudoscalar).

Although the use of Born approximation is not well justified, we compared (3) with the available experimental distributions at several values of the energy with the best statistics [5,6]. In this way we determined in each case the value of μ which gave the best fit. These values of μ(or μ^2) are given in Table I, both for scalar and pseudoscalar K'. The values of $fg/4\pi$ are also indicated for the cases where total cross sections were available. The most probable value was found to be:

$$\mu = 605 \pm 49 \text{ Mev} \quad (K' \text{ scalar}), \qquad (4a)$$

$$\mu = 176 \pm 46 \text{ Mev} \quad (K' \text{ pseudoscalar}) \qquad (4b)$$

The last possibility can be immediatly excluded since it would lead to a fast decay of K into $K' + \pi$. Thus we conclude that the K' (if it exists) is scalar, K being pseudoscalar in agreement with other experimental indications [7].

In Fig. 2 all experimental data are plotted together to give an idea of the goodness of the fitting with a unique mass in the case of scalar K'. In order to do this we introduce the notation (C. M. system):

$$x(\theta,E) = 2\,E_\pi\,E_K\,(1 + v_\pi\,v_K \cos\theta) - (m_\pi^2 + m_K^2)\ , \qquad (5a)$$

$$z^{-2}(\theta,E) = \frac{d\sigma/d\Omega}{\sigma(E)\ L(\theta,E)} \int \frac{L(\theta,E)\ d\Omega}{\left[\mu^2 + x\right]^2}\ , \qquad (5b)$$

$$L(\theta,E) = 1 + v_p\,v_\Lambda \cos\theta + m_\Lambda\,m_p/E_\Lambda\,E_p\ . \qquad (5c)$$

Thus equations (3) imply:

$$z(\theta,E) = \mu^2 + x(\theta,E) \qquad (6)$$

for all energies ($E = E_\pi^{Lab}$) and angles.

The x and z coordinates for each experimental point plotted were obtained from (5) using μ = 605 Mev. The values of $1/\sigma\ \ d\sigma/d\Omega$ and $\cos\theta$ used were the average in the intervals in which the angular distribution histograms, represented as functions of $\cos\theta$, were divided. The straight lines indicated correspond to equation (6) for values of μ = 605, and 605 $\pm$ 49 Mev. The fit of the experimental points in Fig. 2 with these theoretical lines seems to be very good except for the points to the right which correspond to $\cos\theta \sim 1$, as should be expected. These points also have a poorer statistics. The fit in the case of pseudoscalar K' was not so good.

Actually the experimental points plotted are only appropriate for the comparison with the theoretical line for μ = 605 Mev since z_{exp} depends on μ. However for the two other values (605 ± 49 Mev) the experimental points would be only slightly shifted. If we interpret these results as indicating the existence of the K' meson, this meson should have a mass $\mu \geqslant m_K + m_\pi$ for otherwise it would have been already observed. Then K' should be very short lived since the interaction leading to $K' \rightarrow K + \pi$ is strong. However it cannot be excluded that the K' meson does not exist, representing only a pair of π and K, which are exchanged between the baryons and a $KK\pi\pi$-vertex. The existence of the K' can be tested indirectly by the study of the reaction

$$\pi + p \longrightarrow K + \pi + \Lambda \text{ (or } \Sigma \text{)} \tag{7}$$

if the graph of Fig. 3a gives a significant contribution. Thus there should be a characteristic peaking in the energy distribution of Λ (or Σ) in the C. M. system at a point depending on the mass of K'. The values (4a) should not be however taken very seriously due to the approximations made which are more satisfactory for higher π energies. As seen from Table I larger values of μ are obtained at higher energies. Also in this peak the Λ (and Σ) should have some backward preference and strong $K\pi$ angular correlations should be observed. The most spectacular effects of similar kind would occur, however in the reaction

$$N + K \longrightarrow N + K + \pi \tag{8}$$

due to the graph of Fig. 3b.

A more detailed version of the present paper will appear in Anais da Academia Brasileira de Ciências.

Table I. Values of the mass of the hypothetical K' meson and the product of the coupling constants obtained by fitting the experimental data to the theoretical curve.

T^{Lab} (Bev)	K'-scalar μ (Bev)	K'-scalar $fg/4\pi$	K'-pseudoscalar μ^2 (Bev^2)	K'-pseudoscalar $fg/4\pi$
0.902 (5)	0.90 ± 0.20	-	0.048 ± 0.034	-
0.907 (5)	0.66 ± 0.12	-	0.063 ± 0.035	-
0.910 (6)	0.45 ± 0.11	0.33 ± 0.07	-0.012 ± 0.039	0.70 ± 0.10
0.960 (6)	0.49 ± 0.11	0.43 ± 0.09	0.011 ± 0.099	0.91 ± 0.40
1.200 (6)	0.59 ± 0.11	0.31 ± 0.06	0.034 ± 0.039	0.55 ± 0.08
1.300 (6)	0.80 ± 0.12	0.48 ± 0.09	0.103 ± 0.085	0.69 ± 0.08

T_{π}^{Lab} is the kinetic energy of the pion in Lab system.

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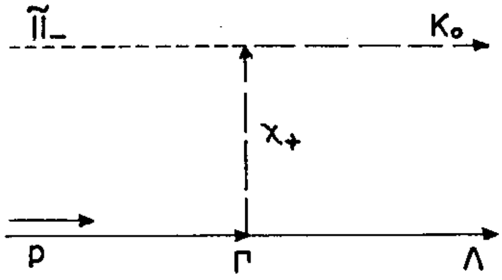


Fig. 1 - Feynman diagram of the assumed predominant contribution to Λ production.

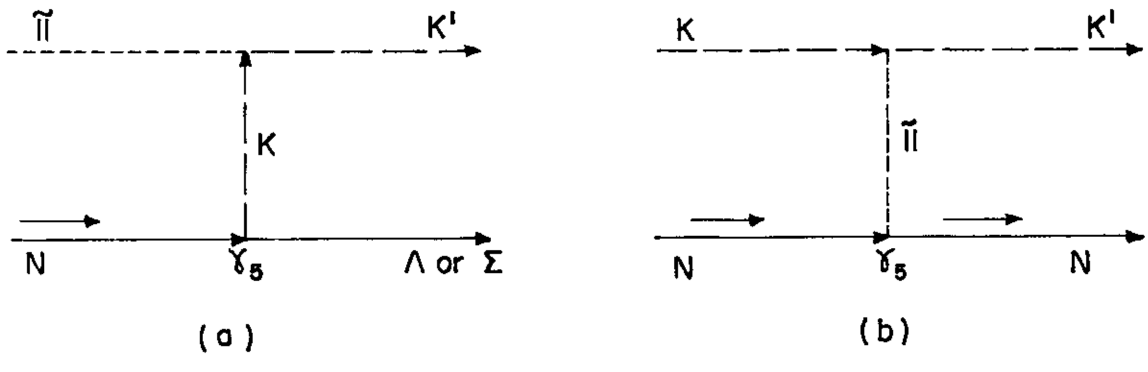
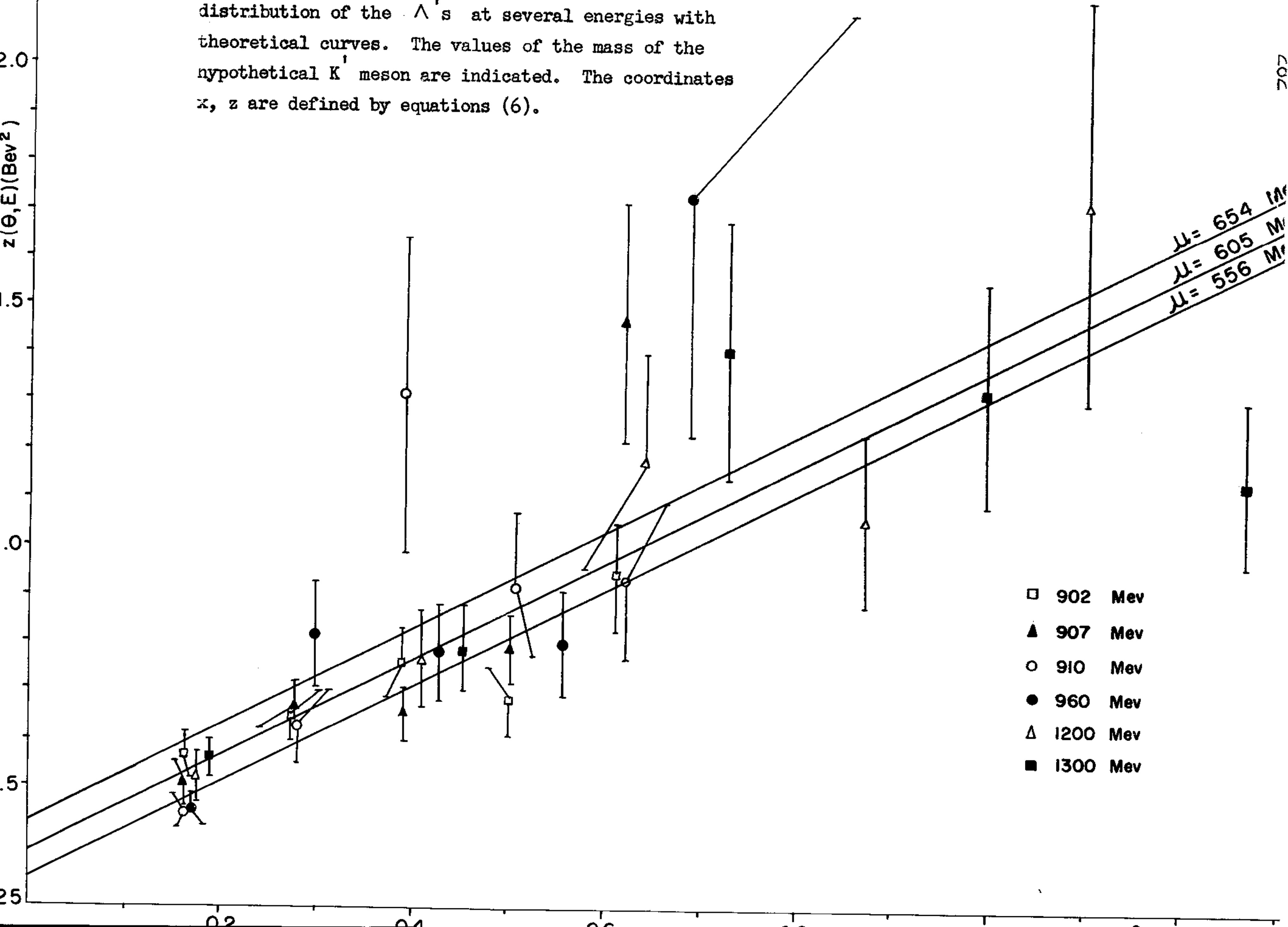


Fig. 3 - Diagrams of: a) π production of K'; b) scattering of K producing a K'.

distribution of the Λ's at several energies with theoretical curves. The values of the mass of the hypothetical K' meson are indicated. The coordinates x, z are defined by equations (6).



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