VALIDITY OF THE DOUBLET SYMMETRY HYPOTHESIS AT HIGH ENERGIES

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Attention is directed to the circumstance that the conclusions resulting from doublet symmetry can be made consistent with the corresponding high-energy experimental data.

PAIS[1] (see also [2]) has considered the question of the symmetry of strong interactions (doublet symmetry hypothesis) connected with the assumption that the interactions of the Λ and Σ hyperons have an identical character. In this case the Lagrangian of the interaction between the baryons and the field of the π and K mesons is invariant under the simultaneous substitutions $\Sigma^+ \to 2^{-1/2}(\Lambda^0+\Sigma^0)$, $2^{-1/2}(\Lambda^0-\Sigma^0)\to\Sigma^-$, $K^+\to K^0$, and $-\bar{K}^0\to K^+$, and the following equations hold for the cross sections of the processes in which strange particles participate[1]:

$$\sigma_{ex}(K^-p\,|\,\bar{K}^0n)=0, \qquad (1)$$

$$\sigma(\pi^-p\,|\,\Sigma^-K^+)=2\sigma(\pi^-p\,|\,\Sigma^0K^0)=2\sigma(\pi^-p\,|\,\Lambda^0K^0) \qquad (2)$$

etc. Equations of type (1) and (2) remain valid also in the case if N pions are created in addition. We then have[1)]

$$\sigma(\pi^-p\,|\,\Sigma^-K^+\underbrace{\pi\ldots\pi}_{N}) = 2\sigma(\pi^-p\,|\,\Sigma^0K^0\underbrace{\pi\ldots\pi}_{N}) = 2\sigma(\pi^-p\,|\,\Lambda^0K^0\underbrace{\pi\ldots\pi}_{N}), \qquad (3)$$

$$\sigma(\pi^-p\,|\,\Sigma^+K^0\underbrace{\pi\ldots\pi}_{N}) = 2\sigma(\pi^-p\,|\,\Sigma^0K^+\underbrace{\pi\ldots\pi}_{N}) = 2\sigma(\pi^-p\,|\,\Lambda^0K^+\underbrace{\pi\ldots\pi}_{N}),$$

$$\sigma(\pi^-p\,|\,K^0\Sigma^-\underbrace{\pi\ldots\pi}_{N}) = \sigma(\pi^-p\,|\,K^+\Sigma^+\underbrace{\pi\ldots\pi}_{N}) = 0. \qquad (4)$$

On the basis of (3) and (4) we obtain equality of the cross sections for the production of neutral and charged hyperons:

$$\sigma_0(\Lambda^0,\Sigma^0)=\sigma_+(\Sigma^+)+\sigma_-(\Sigma^-). \qquad (5)$$

By analogy, we have for the cross sections of the production of pairs of K mesons

$$\sigma_1(K^0\bar{K}^0)=\sigma_2(K^+K^-)\neq 0, \qquad (6)$$

$$\sigma_3(K^0K^-)=\sigma_4(K^+\bar{K}^0)=0. \qquad (7)$$

In addition, the following relations will hold for the interaction reactions between the K^- and K^0 mesons and protons.

$$\sigma(K^-p\,|\,\Lambda^0)=\sigma(K^-p\,|\,\Sigma^0)=\sigma(\bar{K}^0p\,|\,\Sigma^+), \qquad (8)$$

$$\sigma(\bar{K}^0p\,|\,\Lambda^0)=\sigma(\bar{K}^0p\,|\,\Sigma^0)=\sigma(K^-p\,|\,\Sigma^-). \qquad (9)$$

As was already noted by Pais, Eqs. (1) and (2) contradict the experimental data at low energies. We shall discuss below the question of whether Eqs. (1)—(9), which follow from the doublet symmetry hypothesis, can be reconciled with the known experimental data at high energies.

As the first step we consider the behavior of the cross section of the charge-exchange reaction $K^- + p \to \bar{K}^0 + n$ with increasing energy. It follows from the experimental results of Cook et al[3] that when the K-meson energy increases from 0.6 to 3.5 BeV, σ_{ex} decreases by 4—5 times. This gives grounds for hoping that with further increase in the energy the contribution of the scattering with charge exchange can in general be neglected compared, for example, with the contribution of elastic scattering.

As regards, for example, Eq. (5), we have on the basis of the experimental data of Bertanza et al[4], who investigated the production of strange particles in the interaction between 5-BeV negative pions and protons,

$$\sigma_0\approx 2(\sigma_++\sigma_-).$$

It follows therefore that if our hypothesis does not hold at high energies, too, then an energy of 5 BeV is still insufficient for its applicability. Favoring the second deduction are the experimental data at a negative pion energy of 16 BeV[5], from which it follows that

$$\sigma_0=(0.68\pm 0.10)\,\text{mb}\quad \sigma_++\sigma_-=(0.65\pm 0.07)\,\text{mb}$$

1)It must be noted that identical pion aggregates should enter in all the reactions whose cross sections are related by the equations.

Further comparison shows that Eqs. (6) and (7) do not agree with experiment at a negative pion momentum of 2 BeV/c[6], with

$$\sigma_3 \approx 3\sigma_1 \approx 6\sigma_2,$$

but the indicated disagreement becomes smaller when the energy is increased[2)] to 5 BeV. In this case we have[4]

$$\sigma_3 + \sigma_4 \approx \sigma_1.$$

Unfortunately the existing experimental data at high energies do not make it possible as yet to check the other relations.

In spite of this, on the basis of our analysis we can deduce that the agreement between experiment and the conclusions that follow from the hypothesis of the doublet symmetry improves with increasing energy. It is not excluded that such a situation is one of the confirmations of the usually expressed hopes (see for example [8]) that if some laws (symmetries) are violated because of masses or of mass differences, such laws (symmetries) can be exactly satisfied when all the relative energies are large compared with all the masses. We recall that in the case under consideration the symmetry is violated because of the difference in the masses of the Λ and Σ particles.

Further experiments at high energies will make it possible to check the correctness of the noted tendency.

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[2)]It must also be borne in mind here that at high energies part of the K-meson pairs can be formed as the result of the the decay of hypothetical heavy neutral mesons.[7] We then have

$$\overline{\sigma}_p (K^+K^-) = \sigma_p(K^0\overline{K}^0) = {}^1/_2\, \sigma_p(K^+ \overline{K}^0) = {}^1/_2\, \sigma_p (K^0K).$$

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