

$$\sigma_{\pi^+p}^{(tot)} = \sigma_{\pi^-d}^{(tot)} - \sigma_{\pi^-p}^{(tot)} + \Delta_G \sigma$$

and accelerates the decrease of the experimental values of $\Delta_G \sigma$ with increasing E .

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REGENERATION OF K^0 MESONS AND THE POMERANCHUK THEOREM¹⁾

S. S. Gershtein, I. Yu. Kobzarev, and L. B. Okun'

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1. According to data obtained recently in Serpukhov [1], the total cross sections for K^- mesons are constant in the interval 20 - 55 GeV and amount to

$$\sigma_{K^-p} = 21 \pm (0.3 - 0.5) \text{ mb}, \quad \sigma_{K^-d} = 40 \pm (0.4 - 0.8) \text{ mb},$$

$$\sigma_{K^-n} = 20 \pm (0.5 - 1.3) \text{ mb}.$$

The previously obtained [2] data on K^+ mesons are as follows: the cross section σ_{K^+p} , neglecting small deviations ($\sim 0.2 - 0.3$ mb, but at an error of 0.1 mb) is constant in the 6 - 20 GeV/c interval and equals 17.3 mb; $\sigma_{K^+d} = 33.8 \pm 0.3$ mb and $\sigma_{K^+n} = 17.5 \pm 0.4$ mb. (There are no data on K^+ mesons at higher energies). Thus, the data of [1,2] do not contradict the hypothesis that the cross sections of K^+ reach the constant asymptotic limit already starting with 6 GeV/c, and the corresponding value for K^- is 20 GeV/c,²⁾ so that as $E \rightarrow \infty$ we have

$$\sigma_{K^-p} - \sigma_{K^+p} = 3.5 \pm 0.5 \text{ mb}, \quad \sigma_{K^-d} - \sigma_{K^+d} = (6 \pm 1) \text{ mb}$$

(1)

$$\sigma_{K^-n} - \sigma_{K^+n} = 2.5 \pm 1.5 \text{ mb}.$$

Were it not so, this would mean violation of the Pommeranchuk theorem [3], according to which $\sigma = \bar{\sigma}$ as $E \rightarrow \infty$.

Of course, the data of [1, 2] do not prove in any manner that the cross sections σ_{K^+p} and σ_{K^-p} have actually reached their asymptotic constant limits. In particular, one cannot exclude the possibility that the cross section σ_{K^+p} begins to grow, starting with 20 GeV, and to approach σ_{K^-p} . As to σ_{K^-p} , it can be approximated near 20 GeV, at the present accuracy, not only by a horizontal line, but also by a curve having a minimum (the latter possibility

¹⁾Reported at conference on High Energy Physics, Kiev, 22 October 1969.

²⁾The data of [2] do not contradict the assumption that σ_{K^-p} and σ_{K^-d} reach the constant limits at 18 and 14 GeV/c, respectively.

was discussed in [4]). Nevertheless, we deem it timely to discuss the possibility of $\sigma - \bar{\sigma} = \text{const} \neq 0$ as $E \rightarrow \infty$.

The purpose of this paper is to note that the hypothesis $\sigma_{KN} - \bar{\sigma}_{KN} = \text{const} \neq 0$ as $E \rightarrow \infty$ leads to a number of distinct predictions pertaining to K^0 -meson regeneration. Thus, if experiment does not confirm these predictions, this will mean that the hypothesis is incorrect.

2. By virtue of isotopic symmetry

$$\sigma_{K^0 p} = \sigma_{K^+ n}, \quad \sigma_{\bar{K}^0 p} = \sigma_{K^- n}, \quad \sigma_{K^0 n} = \sigma_{K^+ p}, \quad \sigma_{\bar{K}^0 p} = \sigma_{K^- p}, \quad \sigma_{K^- d} = \sigma_{K^+ d}, \quad \sigma_{\bar{K}^0 d} = \sigma_{K^- d} \quad (2)$$

and consequently

$$\sigma_{\bar{K}^0 p} - \sigma_{K^0 p} = 2.5 \pm 1.5 \text{ mb}, \quad \sigma_{\bar{K}^0 n} - \sigma_{K^0 n} = 3.5 \pm 0.5 \text{ mb}, \quad \sigma_{\bar{K}^0 d} - \sigma_{K^0 d} = 6 \pm 1 \text{ mb}. \quad (3)$$

The imaginary part of the forward regeneration amplitude f_{21} is determined by the relation

$$\frac{2 \text{Im} f_{21}}{k} = \frac{\text{Im}(f - \bar{f})}{k} = \frac{\sigma_{K^0} - \sigma_{\bar{K}^0}}{4\pi} = \begin{cases} -0.2 \pm 0.1^2 \text{ mb for } p \\ -0.3 \pm 0.04 \text{ mb for } n \\ -0.5 \pm 0.08 \text{ mb for } d. \end{cases} \quad (4)$$

It is well known (Pomeranchuk [3], Martin [5, 6]) that a constant difference $\sigma - \bar{\sigma}$ should lead to a logarithmically growing ratio of the real and imaginary parts of the crossing-antisymmetrical amplitude, if this amplitude satisfies the dispersion relations. The regeneration amplitude is described in this case by the expression¹⁾

$$f_{21}(E) = E(\ln E + \ln(E)) \frac{\sigma_{\bar{K}N} - \sigma_{KN}}{8\pi^2}, \quad (5)$$

where E is the energy in the lab. It follows from this expression that

$$\frac{\text{Re} f_{21}}{\text{Im} f_{21}} = - \frac{2}{\pi} \ln E. \quad (6)$$

At energies below 6 GeV we have $\text{Re} f_{21}/\text{Im} f_{21} = +1$, cf. [7, 8]. Thus, the real part of f_{21} should reverse sign with increasing energy, and should then start to increase like $E \ln E$. A rough estimate based on the assumption that f_{21} is a sum of two terms, one of the Regge type and the other of the form (5), shows that this sign reversal can occur in the region of 20 GeV. This estimate, however, is very unreliable.

The logarithmic growth of the regeneration amplitude at zero angle should lead, by virtue of unitarity, to the result that the amplitude $f_{21}(t)$, as a function of the 4-momentum squared t , should have a cone that becomes narrower with increasing energy²⁾, so that

$$t_{\text{eff}}(\ln E)^2 \leq \text{const}. \quad (7)$$

Such a behavior is equivalent to having the impact distances ρ , over which the regeneration takes place, increase logarithmically with energy, $\rho \sim \ln E$.

It follows from the foregoing that regeneration experiments with the Serpukhov accelera-

¹⁾ The corresponding expression in [5, 6] contains an error in sign, and increases logarithmically when $\sigma = \bar{\sigma}$.

²⁾ V. N. Gribov, I. Ya. Pomeranchuk, private communication, 1961-62, Eden [9].

tor are of prime importance. (Such experiments were discussed earlier by Okonov [10].)

3. Of course, were these experiments to confirm the foregoing predictions, this would still not mean that violation of the Pomeranchuk theorem is proved, since there can exist non-asymptotic regimes that lead to analogous relations in a finite energy interval. Thus, for example, if $\sigma - \bar{\sigma}$ is sufficiently close to a constant in a sufficiently wide energy interval ($E_1 < E < E_2$), we obtain from the dispersion relation for f_{21}

$$\operatorname{Re}[f_{21}(E) - f_{21}(m_K)] = \frac{2E^3}{\pi} P \int_0^\infty \frac{\operatorname{Im} f_{21}(E') dE'}{E'^2(E'^2 - E^2)}, \quad (8)$$

following Pomeranchuk [3], in the case $E_1 \ll E < E_2$:

$$\frac{\operatorname{Re} f_{21}}{\operatorname{Im} f_{21}} \approx -\frac{2}{\pi} \ln \frac{E}{E_1} \left(1 + \frac{E^2}{2E_2^2}\right) + c, \quad (9)$$

which at sufficiently small c and at $(E_2 - E)/E_2 \sim 1$ goes over into $-(2/\pi)\ln(E/E_1)$, coinciding with (6).

By virtue of (3), the prediction for $\operatorname{Im} f_{21}$ has better accuracy in the case of regeneration on deuterium than in the case of hydrogen.

The main results on regeneration at energies 1 - 6 GeV have been obtained so far for the nuclei C, Cu, and Pb. (We know of only one investigation in which hydrogen was used [11].) The phase of f_{21} is practically the same for the different nuclei ($\phi_{21} \approx -3\pi/4$); according to [6], both ϕ_{21} and $|f_{21}|$ are in good agreement with optical-model calculations. This allows us to conclude that relatively easier experiments on nuclei (and not only hydrogen or deuterium), when performed at Serpukhov energies, can yield (in conjunction with optical-model calculations) sufficiently reliable information on the amplitudes of regeneration on nucleons, and consequently can answer the questions discussed above.

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