DISPERSION RELATIONS AND CHARGE EXCHANGE REACTION $\pi^- p \to \pi^0 n$ AT HIGH ENERGIES

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It is shown that to obtain agreement with experiment it is necessary to make one substraction in the dispersion relations for the amplitude of the charge exchange $\pi^- p \to \pi^0 n$. The real part of the amplitude and $d\sigma^{ex}/dt$ tend in this case to constant values at t = 0 and $E \to \infty$, thus contradicting the model of complex angular momenta.

The differential charge-exchange cross section at t = 0 can be calculated with the aid of the dispersion relations and isotopic invariance if one knows the difference $\Delta\sigma$ between the total $\pi^{\pm} p$ scattering cross sections, namely,

$$d\sigma^{ex}/dt = 22{,}5(\Delta\sigma^2 + R^{(-)2}) . \tag{1}$$

Here and below $d\sigma^{ex}/dt$ is in $\mu b/(GeV/c)^2$ while $\Delta\sigma$ and the real part $R^{(-)}$ of the amplitude are in millibarns.

We have first obtained $R^{(-)}$ at E >> 1 GeV from the dispersion relations without subtractions, in the form

$$R^{(-)} = \frac{2}{\pi} \int_0^\infty \frac{dp' p'^2 \Delta\sigma}{E'(E'^2 - E^2)} . \tag{2}$$

Here p is the momentum and E the energy of the pion in the laboratory system. For $\Delta\sigma$ at E > 8 GeV we used the parametrization

$$\Delta\sigma \equiv \sigma_- - \sigma_+ = Q/E^A . \tag{3}$$

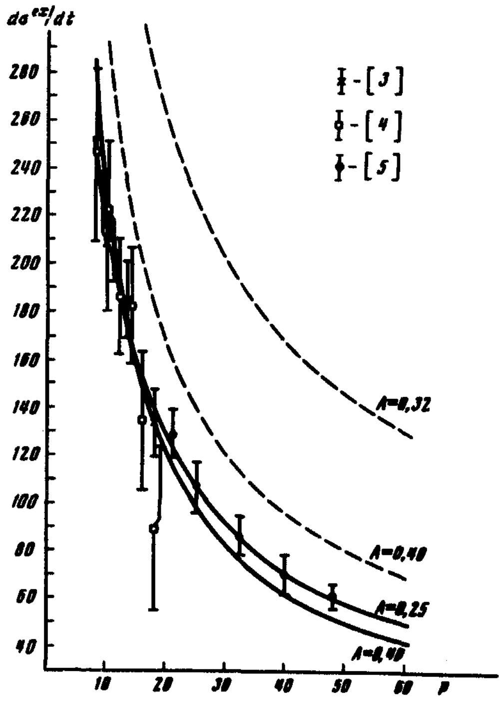

Fig. 1

The calculations were performed for many values of the parameter A in the interval from 0.25 to 0.40, which covers with large margin the range of variation of this parameter, 0.32 ± 0.02, obtained in experiments by the Brookhaven group [1] and with the Serpukhov accelerator [2]. The parameter Q at fixed A was obtained from the minimum χ^2 condition.

The correction to formula (3) for $\Delta\sigma$, which arises in the theory of complex angular momenta when account is taken of the contributions from the cuts, reduces effectively to a redefinition of the constant A and does not influence our results.

The values of $d\sigma^{ex}/dt$ calculated from formula (1) approach the experimental points [3 - 5] with increasing A, but even at A = 40 there is no agreement with experiment (Fig. 1, dashed lines).

It is thus obvious that to determine $R^{(-)}$ it is necessary to use dispersion relations with subtraction

$$R^{(-)} = G + \frac{2E^2}{\pi}\int_0^\infty \frac{dp'\,\Delta\sigma}{E'(E'^2-E^2)} \qquad (4)$$

By suitably choosing the subtraction constant G we can obtain good agreement between the calculated $d\sigma^{ex}/dt$ and the experimental data for all values of A in the interval from 0.25 to 0.40 (Fig. 1, solid lines).

The discrepancy between (2) and experiment can be attributed to the fact that actually $\Delta\sigma \to$ const as $E \to \infty$. Such a possibility, which corresponds to violation of the Pomeranchuk theorem, is considered in [6].

On the other hand, if $\Delta\sigma$ does satisfy the Pomeranchuk theorem and is described by relation (3), then it follows from our calculations that $R^{(-)} \to C \neq 0$ as $E \to \infty$. This result contradicts the predictions of the complex angular momentum model.

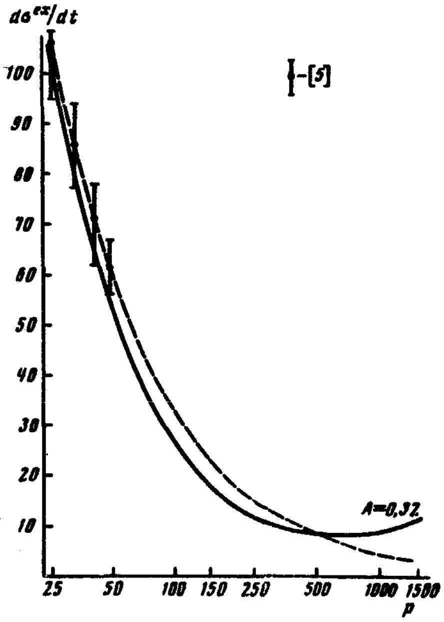

Fig. 2.

The dispersion relation (4) reduces in this case to relation (2), in which the constant C is added on the right. C = -1.2 mb for A = 0.32. Then $d\sigma^{ex}/dt(\infty)$ = 37 $\mu b/(GeV/c)^2$. (At A = 0.4 these quantities are equal to -0.5 mb and 6.5 $\mu b/(GeV/c)^2$, respectively.)

At energies 10 GeV $\leq E \leq$ 60 GeV the experimental points fit well the curve $d\sigma^{ex}/dt = 1590/E^{0.84}$ [5]. This curve is shown dashed in Fig. 2, together with the dispersion curve obtained from (4) at A = 0.32. In the investigated energy range E < 60 GeV, these curves practically coincide. In the region 100 GeV $\leq E \leq$ 220 GeV the discrepancy between them becomes appreciable, on the order of 25%. The curves subsequently intersect and diverge above 600 GeV.

It is clear from the foregoing calculations that measurement of $\Delta\sigma$ as well as of the charge-exchange cross section at energies above 60 GeV is extremely important for models of high-energy scattering.

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