REAL PART OF THE pn FORWARD SCATTERING AMPLITUDE AND THE np CHARGE EXCHANGE

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The real part of the pn forward scattering amplitude has been evaluated in the energy range from 1.5 GeV/c to 60 GeV/c. The calculations are based on the strict equality which connects the real and imaginary parts of the pn and pp forward scattering amplitudes with the np charge exchange cross section in the forward direction, provided that strong interactions are isotopically invariant and spin effects are negligible.

Contrary to the real part of the pp forward scattering amplitude, which is rather well known from experiment and from theoretical calculations (see, e.g., review [1]), both the experimental and the theoretical knowledge of the real part of the pn forward scattering amplitude is very poor (see Fig. 29 in the review [2]): the dispersion relation predictions have large uncertainties and experimental data are with large errors.

In this letter we propose to use the simple formula

$$\alpha_{\rm pn} = \frac{\alpha_{\rm pp}\sigma^{\rm tot}_{\rm pp} \pm \sqrt{0.16\pi(\hbar c)^2 \dfrac{d\sigma^{\rm ch}(0^0)}{dt} - (\sigma^{\rm tot}_{\rm pp} - \sigma^{\rm tot}_{\rm pn})^2}}{\sigma^{\rm tot}_{\rm pn}} \tag{1}$$

for evaluating the real part of the forward pn scattering amplitude. Here α is ratio of forward real part to the imaginary part of the scattering amplitude, $\sigma^{\rm tot}$ is the total cross section, measured in mb, $d\sigma^{\rm ch}(0^\circ)/dt$ is the np charge exchange cross section in the forward direction in μb/(GeV/c)^2 and $\hbar c = 0.1973$ fm GeV. Eq. (1) is a strict consequence (see e.g. [3]) of the isotopic invariance of strong interactions and it should be valid at all energies provided that spin effects are negligible. The use of this equation at many energies has become feasible only now, when data on the np charge exchange cross section have become available in a wide energy range.

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We have fitted the functional form

$$\frac{d\sigma^{ch}(0^0, p)}{dt} = Ap^{-2} + Bp^{\gamma} \quad (2)$$

to the data in the energy interval from 1.40 GeV/c to 62.5 GeV/c [4–9]. Here p is the lab momentum of the nucleon, A, B and γ are parameters to be determined from the fit. This particular form of parametrization was chosen because it was known beforehand that up to $\sim$ 25 GeV/c the first term was sufficient to describe the behaviour of $d\sigma^{ch}(0°, p)/dt$. At higher energies the data [4] show deviations from the simple p^{-2} law. The second term in Eq. (2) was introduced to account for this experimental fact. Very good fit was obtained with the following values of parameters: $A = 100445$, $B = 9.65$, $\gamma = 0.23$[1]. Data on total

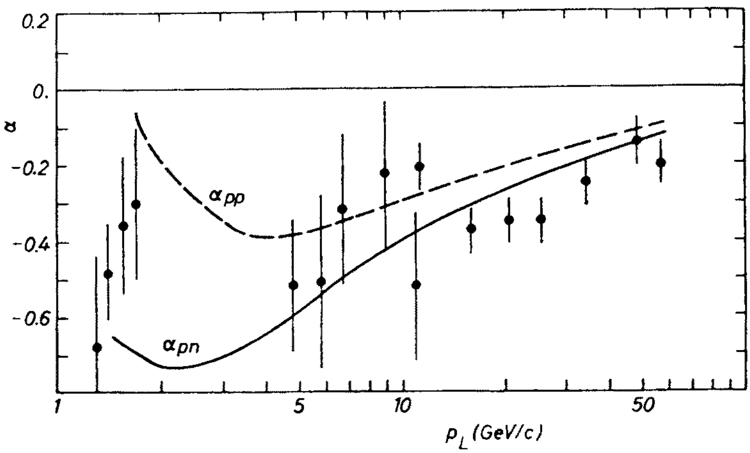

Fig. 1. Ratio of forward real part to the imaginary part of the scattering amplitude as a function of protons laboratory momentum. The dashed curve corresponds to α_{pp} and was used as the input, the solid curve corresponds to α_{pn} and results from Eq. (1) where the square root was taken with the minus sign. The solution with the positive branch of the square root gives very large values of α_{pn}, it was considered as unphysical and is not shown in the figure. The experimental points refer to α_{pn} and corresponding references can be traced in the review [2]

cross sections in the aforementioned region were taken from papers [10, 11]. For α_{pp} we have used the recent dispersion relation predictions [12].

The results of calculations are presented in the Figure.

It is seen that at low and medium energies ($p \lesssim 10$ GeV/c) the pn forward scattering amplitude is much more real than the pp forward scattering amplitude. Qualitatively

[1] We stress that we do not attempt to attach any physical meaning neither to the second term in Eq. (2) nor to the actual value of γ. This term was introduced only in order to improve the fit to the existing data on $d\sigma^{ch}(0°, p)/dt$. Obviously, other parametrizations could be equally good. But this is of no relevance for us as long as we use parametrization (2) only as an interpolating formula in the region of existing measurements and do not try to make any predictions about the behaviour of $d\sigma^{ch}(0°, p)/dt$ at higher or lower energies. This is out of the scope of the present paper.

this agrees well with what can be concluded also from the most recent dispersion relation predictions [13] (compare Figs 6a and 6b of that paper).

We do not ascribe any errors to our predictions for α_{pn}. In any case, they are not smaller than the errors of α_{pn} estimated in [13] (see Fig. 6b of that paper), where they were attributed mainly to uncertainties in σ_{pn}^{tot}. In our case additional errors come from uncertainties in $d\sigma^{ch}(0°, p)/dt$ (normalization, extrapolation of the differential cross section to the forward direction) and from uncertainties in the dispersion relation predictions for α_{pp}. Nevertheless, we believe that with the improvement of accuracy of experiments the Eq. (1) could become a valuable tool in testing the mutual consistency of the nucleon-nucleon forward scattering and the charge exchange data.

Perhaps it would be interesting to extend the use of this equation both to lower and higher energies. At low energies it could serve as a detector of a spin: deviations from Eq. (1) would mean the presence of spin effects. On the other hand, at high energies this equation predicts how fast $\alpha_{pn} \to \alpha_{pp}$. Unfortunately, though the $d\sigma^{ch}(0°)/dt$ data are already available up to 300 GeV/c [14], the practical use of Eq. (1) is hindered by the confusion concerning the experimental data on the cross section difference $\sigma_{pp}^{tot} - \sigma_{pn}^{tot}$ at high energies, $p \gtrsim 60$ GeV/c (see discussion on this last point in the review [15]).

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