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# Pion Charge Exchange Scattering at High Energies

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*Abstract*

By a phenomenological choice of the residue functions, a very good fit with experiment for the pion–nucleon charge exchange reaction at Fermilab energies is obtained on a simple Regge-pole model using a quadratic $\rho$ trajectory and energy-independent parameters.

## Introduction

The pion–nucleon charge exchange reaction has been extensively studied both experimentally and theoretically. However, as the neutral particles produced in a scattering process are difficult to detect, the experimental results for the charge exchange process are considerably less precise than the results for elastic scattering. At high energies, although the detection of the neutral particles becomes easier, the charge exchange cross section becomes very small, and the background from multipion events becomes important.

The differential cross section for the pion–nucleon charge exchange reaction and the difference $\Delta\sigma = \sigma(\pi^- p) - \sigma(\pi^+ p)$ between the total cross sections have been measured in the high energy region by Bolotov *et al.* (1972), Gorin *et al.* (1972), Carroll *et al.* (1974, 1976) and Barnes *et al.* (1976). However, different sets of data are contradictory. In particular, the Serpukhov data (Bolotov *et al.* 1972; Gorin *et al.* 1972) are clearly not compatible with the Fermilab data (Barnes *et al.* 1976) for the charge exchange. We confine our attention here to the Fermilab data.

The main characteristics of the high energy charge exchange angular distribution are as follows.

(1) The angular distribution has a diffraction-type pattern in the range $0 \leqslant -t \leqslant 0\cdot 5\ (\mathrm{GeV}/c)^2$.

(2) For $-t \leqslant 1\cdot 5\ (\mathrm{GeV}/c)^2$, the angular distribution has two dips: one at $t = 0$ and the other at $-t \approx 0\cdot 6\ (\mathrm{GeV}/c)^2$.

(3) In the interval $0\cdot 5 < -t < 1\cdot 2\ (\mathrm{GeV}/c)^2$, the angular distribution is parabolic.

(4) The differential cross section decreases with increase in energy.

Recently Nakata (1977) has stated that a pure $\rho$ Regge-pole exchange model is not sufficient to explain the $\pi^- p \to \pi^0 n$ characteristics. His analysis is based on the

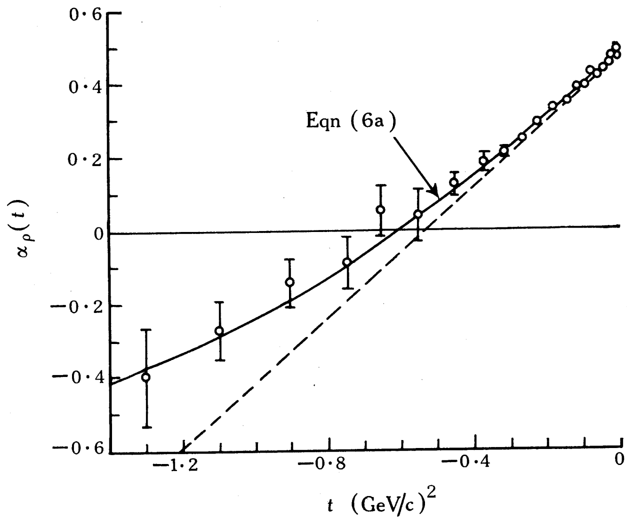


**Fig. 3.** Comparison of the present $\rho$ trajectory $\alpha_\rho(t)$ given by equation (6a) with the results derived from the experimental data of Barnes *et al.* (1976). The dashed line corresponds to both $\rho$ and g mesons.

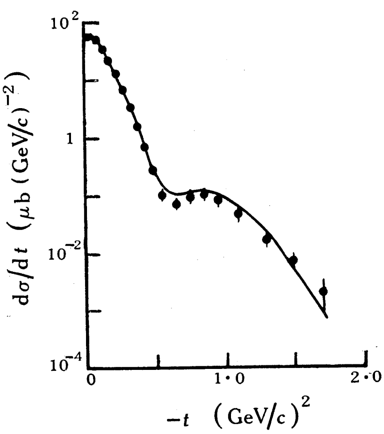


**Fig. 4.** Fit of the present model to the experimental differential cross section obtained by Apel *et al.* (1977) for the $\pi^-p \rightarrow \pi^0n$ reaction at 40 GeV/$c$.

this singularity does not occur in the physical region where the experimental measurements are made and therefore does not influence our analysis of the problem.

The results of comparisons of our model with experimental data are given in Figs 1–4. The fits to the differential cross sections of Barnes *et al.* (1976) are shown in Fig. 1, while the difference $\Delta\sigma$ between the $\pi^-p$ and $\pi^+p$ total cross sections is plotted as a function of the incident pion momentum $p_{lab}$ in Fig. 2. The $\rho$ trajectory $\alpha_\rho(t)$ obtained from the overall fit (equation 6a) is shown by the full curve in Fig. 3, together with the 'data points' of Barnes *et al.* (1976). More recently, Apel *et al.* (1977) have measured the $\pi^-p \rightarrow \pi^0n$ differential cross section at 40 GeV/$c$ up to $-t \approx 1{\cdot}8$ (GeV/$c$)$^2$. The fit to these data from our model is again good, as shown in Fig. 4.

form of the rest of the angular distribution curve is ignored. However, following Saleem *et al.* (1978), we have taken the form of the whole curve into consideration

We may conclude that a simple Regge-pole model can give a satisfactory account of the $\pi^- p \to \pi^0 n$ characteristics. The polarization at Fermilab energies for this reaction has not yet been measured. Our model predicts it to be zero, but observation of an unexpected nonzero polarization at high energies would necessitate a modification of this simple model.

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