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THE ρ +R MODEL AND pn CHARGE EXCHANGE SCATTERING

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ABSTRACT

From medium energy nucleon-nucleon data it is concluded that a consistent description in terms of Regge poles is possible only if the polarization is non-zero in $\pi^-p \rightarrow \pi^0n$ or $\pi^-p \rightarrow \eta n$ at medium energies.

It is commonly believed that pn charge exchange is one of the triumphs of the Regge pole theory ^{1),2)}. We want in this letter to report on a part of a study we made in parametrizing total cross-sections by means of a Regge-like power expansion in s , the c.m. energy squared. What we want to stress is that just ρ and R together cannot simultaneously explain $\sigma_T(pn) - \sigma_T(pp)$ and $(d\sigma/dt)(pn \rightarrow np)|_{t=0}$ down to $P = 2.83$ GeV/c. In this we disagree with an earlier result ¹⁾.

We parametrized our amplitudes in the forward direction in the following manner :

$$A(pn \rightarrow np) = \rho + R \quad (1)$$

$$A(p\bar{p} \rightarrow n\bar{n}) = -\rho + R \quad (2)$$

where

$$\rho = D_\rho \left(\frac{s}{s_0} \right)^{\alpha_\rho} \left(i + \tan \frac{\pi \alpha_\rho}{2} \right) \quad (3)$$

$$R = D_R \left(\frac{s}{s_0} \right)^{\alpha_R} \left(i - \cot \frac{\pi \alpha_R}{2} \right) \quad (4)$$

The relation between energy dependence and phase follows from the Regge pole model and the normalization is such that

$$\begin{aligned} \sigma_T(pn) - \sigma_T(pp) &= \frac{M}{q\sqrt{s}} \left\{ \text{Im } A(pp) - \text{Im } A(pn) \right\} \\ &= \frac{M}{q\sqrt{s}} \text{Im } A(pn \rightarrow np) \end{aligned} \quad (5)$$

and

$$\frac{d\sigma}{dt}(pn \rightarrow np) \Big|_{t=0} = \frac{1}{16\pi s} \left(\frac{M}{q} \right)^2 |A(pn \rightarrow np)|^2 \quad (6)$$

2.

In formulae (3)-(6), α_ζ and α_R are the intercepts of the ζ and the R trajectories at zero momentum transfer, D_ζ and D_R are proportional to the residues of the Regge poles, M is the nucleon mass and q the centre-of-mass three-momentum. $A(pp)$ is the amplitude for elastic pp scattering, $A(pn)$ for pn elastic scattering and $A(pn \rightarrow np)$ and $A(p\bar{p} \rightarrow n\bar{n})$ the amplitudes for the charge exchange reactions. $\sigma_T(pp)$ and $\sigma_T(pn)$ denote the total cross-sections for pp and pn scattering.

It is an experimental fact that the difference $\sigma_T(pp) - \sigma_T(pn)$ changes sign ³⁾ at $P \approx 3.7$ GeV/c and becomes negative at higher energy. This is easily explained from Eqs. (1), (3), (4) and (5) by giving D_ζ and D_R opposite signs.

From an analysis of the energy dependence of the process $\pi^- p \rightarrow \pi^0 n$, α_ζ is very well determined ⁴⁾ to be 0.57, while α_R is determined ⁵⁾ from the process $\pi^- p \rightarrow \gamma n$ to be 0.4. As the values of α_ζ and α_R are known, the zero of $\sigma_T(pn) - \sigma_T(pp)$ fixes the ratio D_ζ/D_R and only one parameter remains to be fixed.

Assuming D_ζ and D_R to have opposite signs, makes the imaginary parts to cancel [in (1)] and the real parts to add [in (2)] and the amplitude $A(pn \rightarrow np)$ is almost completely real for a wide energy range. As a consequence, one sees from Eqs. (3), (4) and (6) :

$$\left. \frac{d\sigma}{dt} (pn \rightarrow np) \right|_{t=0} \sim \frac{[C_1 s^{0.57} + C_2 s^{0.40}]^2}{s q^2} \sim \frac{1}{s}$$

C_1 and C_2 are positive constants.

The experimental data ^{2), 6)} show, however, that from $P = 2.83$ to $P = 8$ GeV/c, $d\sigma/dt$ is roughly proportional to $1/s^2$. How bad is the situation - can best be seen from some numbers. Choosing $s_0 = 1(\text{GeV})^2$ and making a least square fit to measured total cross-sections in pp, $\bar{p}p$, $\bar{p}n$, and pn scattering above $P = 3$ GeV/c in terms of the Regge poles P, P', ζ , ω and R we find

$$D_S = -11.0 \pm 0.4 \text{ mb} \cdot \text{GeV}/c$$

$$D_R = 16.0 \pm 0.6 \text{ mb} \cdot \text{GeV}/c$$

These values give at $P = 8 \text{ GeV}/c$ a value of $(d\sigma/dt)(pn \rightarrow np)$ which is a factor 60 too big. If, on the other hand, we restrict ourselves to fit data above $6 \text{ GeV}/c$, we find $D_S = 0.23 \pm 0.77$, $D_R = -1.96 \pm 1.25 \text{ mb GeV}/c$, which give a value for the charge exchange cross-section at $t=0$ that is compatible with experiment, but only for $P > 6 \text{ GeV}/c$. This set of values does not, however, give the change in sign of $\sigma_T(pn) - \sigma_T(pp)$.

If one wants to fit nucleon-nucleon data at medium energies down to $3 \text{ GeV}/c$, one would need at least a new ζ trajectory : ζ' or a new R : R' . The ζ' would then contribute to $\pi^- p \rightarrow \pi^0 n$, the R' to $\pi^- p \rightarrow \eta n$ and one would then, at medium energies, get a non-vanishing polarization in one of these processes. The success in explaining them by only one trajectory in the medium energy range would then be just good luck.

The conclusion we have reached is : if the Regge pole approach is going to work for medium energy N-N interactions, one expects - at least in this energy region - a non-vanishing polarization effect either in $\pi^- p \rightarrow \pi^0 n$ or in $\pi^- p \rightarrow \eta n$.

R E F E R E N C E S

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