Regge Poles with Absorptive-Correction Cuts and Exchange Degeneracy in the Reaction $\pi^- p \to \eta n$

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(Received 4 October 1968)

A Regge-pole model with absorptive corrections is used to fit the differential cross sections for the reaction $\pi^- p \to \eta n$. This model, unlike the pure Regge-pole A_2-exchange model, also predicts a nonzero polarization. Exchange degeneracy is assumed for residues and trajectory. Thus, previous work on πN scattering and KN scattering is used to fix the trajectory of the A_2 and its residue functions. SU_3 is also used to determine the size of the residues. Only a small amount of SU_3 breaking (10%) is needed to fit the data.

RECENTLY, calculations using an eikonal Regge-pole model have been quite successful in fitting differential cross sections and polarizations for the reactions $\pi^\pm p \to \pi^\pm p$ and $\pi^- p \to \pi^0 n$,[1] and $K^\pm p \to K^\pm p$, $K^\pm n \to K^\pm n$, $K^- p \to \bar{K}^0 n$, and $K^+ n \to K^0 p$.[2] These calculations used exchange degeneracy for the ρ and A_2 residues and trajectories and also for the ω and $f^0(P')$. With the assumptions of exchange degeneracy and SU_3, we can therefore predict, with one extra noncontroversial assumption, the cross section and polarization for the reaction $\pi^- p \to \eta n$.

This calculation should not be considered to be a "best fit" to the data, but it is rather a zero-parameter prediction except for a small (10%) adjustment in coupling strength. This approach should be contrasted with other many-parameter fits[3] which use quite different Regge trajectories for the A_2 and the ρ, thus severely breaking exchange degeneracy.

We start with an impact-parameter representation for the amplitudes G_+ and G_-, which correspond to helicity nonflip and helicity flip, respectively[4]:

$$G_+ = kW\int_0^\infty bdb\, J_0(b\Delta)\chi_0(s,b)[1+i\chi^P(b)], \quad (1)$$

$$G_- = kW\int_0^\infty bdb\, J_1(b\Delta)\chi_f(s,b)[1+i\chi^P(b)]. \quad (2)$$

Since we will deal only with small momentum transfers ($|t| \leqslant 1$ GeV^2), we have considered only the effect of the lowest-order absorptive cut. The functions $\chi_0(s,b)$ and $\chi_f(s,b)$ are obtained by performing a Fourier-Bessel transform on the Regge amplitudes for A_2 exchange. $\chi^P(b)$ is obtained by Fourier-Bessel transforming the Pomeranchon amplitude, which has the form (pure helicity nonflip)

$$G_+{}^P = iCkW[\mu^2/(\mu^2+\Delta^2)]^4, \quad (3)$$

giving

$$\chi^P(b) = i(C\mu^2/48)(\mu b)^3 K_3(\mu_b). \quad (4)$$

In order to write Eqs. (1) and (2), we have assumed that the absorption for ηn is the same as the absorption for πp. Hence, we take for C and μ the values found by Arnold and Blackmon[1]:

$$C = 5.35\ \text{GeV}^{-2}, \quad \mu = 1.1\ \text{GeV}.$$

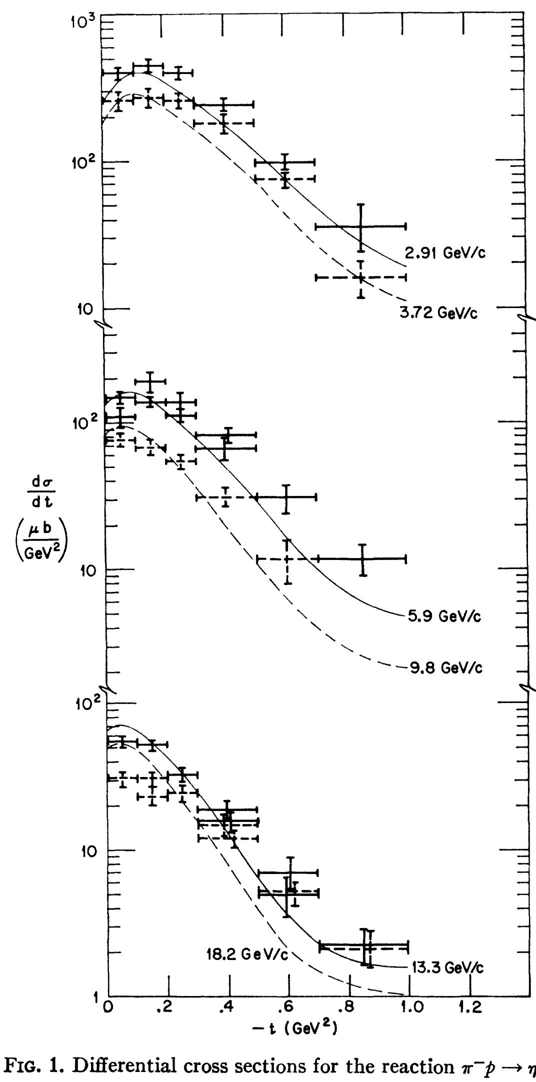

FIG. 1. Differential cross sections for the reaction $\pi^- p \to \eta n$.

[1] Richard C. Arnold and Maurice L. Blackmon, Phys. Rev. **176**, 2082 (1968).
[2] Maurice L. Blackmon and Gary R. Goldstein, Phys. Rev. **179**, (1969).
[3] D. D. Reeder and K. V. L. Sarma, Phys. Rev. **172**, 1566 (1968).
[4] Richard C. Arnold, Phys. Rev. **153**, 1523 (1967).

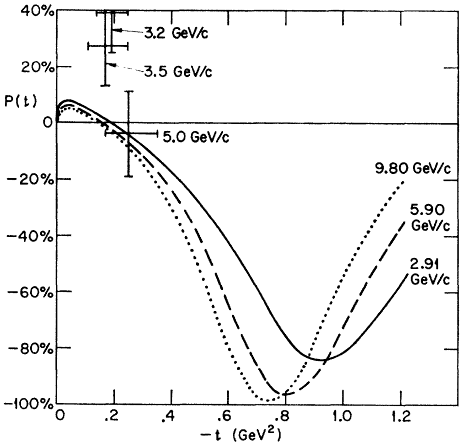

FIG. 2. Polarization for the reaction $\pi^- p \rightarrow \eta n$ produced by absorptive corrections. Data points [D. D. Drobnis *et al.*, Phys. Rev. Letters **20**, 274 (1968); A. Yokosawa, *ibid.* **20**, 566 (1968)] are at 3.2, 3.5, and 5.0 GeV/c.

For the A_2-exchange Regge amplitudes, we assume

$$G_+ = \frac{1+e^{-i\pi\alpha}}{\sin\pi\alpha}\alpha b_1(t)\left(\frac{s}{s_0}\right)^\alpha, \qquad (5)$$

$$G_- = \frac{1+e^{-i\pi\alpha}}{\sin\pi\alpha}\alpha[b_1(t)-b_2(t)]\frac{\Delta}{2M}\left(\frac{s}{s_0}\right)^\alpha. \qquad (6)$$

As in Ref. 2, we write

$$\frac{1+e^{-i\pi\alpha}}{\sin\pi\alpha} = \frac{e^{-i\frac{1}{2}\pi\alpha}}{\sin\frac{1}{2}\pi\alpha}.$$

Since $\alpha/\sin\frac{1}{2}\pi\alpha$ is a slowly varying function in the region of interest $(0 \lesssim |\alpha| \lesssim \frac{1}{2})$, we take $(\alpha/\sin\frac{1}{2}\pi\alpha)\, b_1$ and $(\alpha/\sin\frac{1}{2}\pi\alpha)b_2$ to be constants, A and B, respectively. In Refs. 1 and 2, we used $B=6A$, and we assume that here also.

To estimate the size of A, we first note that in Ref. 2 the value obtained for $2b_1^{K^+K^-\rho^0}$ was 0.65. Exchange degeneracy gives $2b_1^{K^+K^-A_2}=0.65$ also. SU_3 gives (pure d-type coupling)

$$g^{\pi^-\eta A_2^+} = (2/\sqrt{3})g^{K^+K^-A_2^0}$$

and isospin gives $g^{p\bar{n}A_2^-}=\sqrt{2}g^{p\bar{p}A_2^0}$. Hence, one expects $b_1^{\pi\eta A_2^+}=(2\sqrt{\frac{2}{3}})b_1^{K^+K^-A_2^0}$. Since $\langle\alpha/\sin\frac{1}{2}\pi\alpha\rangle\simeq 0.7$, we find, after combining all factors, that $A\simeq 0.37$. To obtain the fits presented, we have used $A=0.40$, which is a small amount of SU_3 breaking. For the A_2 trajectory, we use the fits from Refs. 1 and 2:

$$\alpha = 0.55 + 0.8t.$$

The results of our calculation are shown in Figs. 1 and 2. The differential cross section has been measured for six energies.[5] Only the highest-energy cross section is fitted poorly, where the calculated cross section is too large near $t=0$ and is too small for $-t \gtrsim 0.6$ GeV^2. The rest of the data are fitted satisfactorily.

Finally, the cuts from the absorptive correction produce a polarization, unlike the pure pole model. The qualitative features are the same as those found in the reaction $\pi^- p \rightarrow \pi^0 n$.[1] Here, however, the large negative spike is considerably broader and is located at larger values of $-t$. Since we have not included the P' trajectory in the present calculation, the low-energy small-$|t|$ polarization is smaller than that found by Arnold and Blackmon. Therefore, we must consider the 2.91- and 3.7-GeV/c results to be underestimates of the polarization. The $P'A_2$ cut, however, decreases rapidly with energy, and the polarization above 5–6 GeV/c should be dominated by just the PA_2 cut.

I would like to thank R. C. Arnold for comments and suggestions.

[5] O. Guisan *et al.* Phys. Letters **18**, 200 (1965).