Analysis of backward πN scattering using complex Regge poles

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The current data on backward πN scattering cross sections and polarization, including CERN-I.P.N. Orsay-Oxford measurements, are analyzed using complex Regge poles. Good fits are obtained with complex N_α, N_γ, and Δ_δ trajectories. There are no MacDowell partners and each trajectory produces the usual baryon spectrum at positive u.

In a previous work[1] excellent fits to the πN differential cross-section data were obtained using the complex-Regge-pole model (CRP).[2,3] The trajectories were generated from a D function with fixed cut and square-root singularity at the branch point. N_α and Δ_δ trajectories were assumed to dominate the u-channel exchange. There were no MacDowell partners and the two trajectories were consistent with the usual baryon spectrum at positive u.

Predictions were also given for π^+p and π^-p elastic polarizations in the backward direction at $P_{\rm lab} = 5.9$ BeV/c. However, subsequent CERN–I.P.N. Orsay-Oxford measurements[4,5] of backward polarization at $P_{\rm lab} = 6$ BeV/c have demonstrated that these predictions were incorrect and have posed a challenge to pole and cut models alike. In fact, some authors have argued that the conventional pole and cut models are incapable of fitting the data.[6]

In the present work we have retained the essential features of the previous model except that in addition to N_α and Δ_δ exchange, N_γ exchange is also used. This has resulted in successful fits to the existing πN backward cross section and polarization data with trajectories that produce the usual baryon resonances and no MacDowell partners.

We shall now review the formalism of the model. As before, the D function takes the form

$$D(j,W) = j - \alpha_0(W) - 2\beta(W)(j-\alpha_c)^{1/2}, \tag{1}$$

with $u = W^2$ and

$$\alpha_0(W) = a + bW + cW^2, \tag{2}$$

$$\beta(W) = dW. \tag{3}$$

This leads to trajectories α_1 and α_2 given by

$$\alpha_{1,2} = a + bW + (2d^2+c)W^2 \pm 2dW[(a-\alpha_c) + bW + (d^2+c)W^2]^{1/2}. \tag{4}$$

Then, using the BMZ approximation[2] the amplitudes become[1]

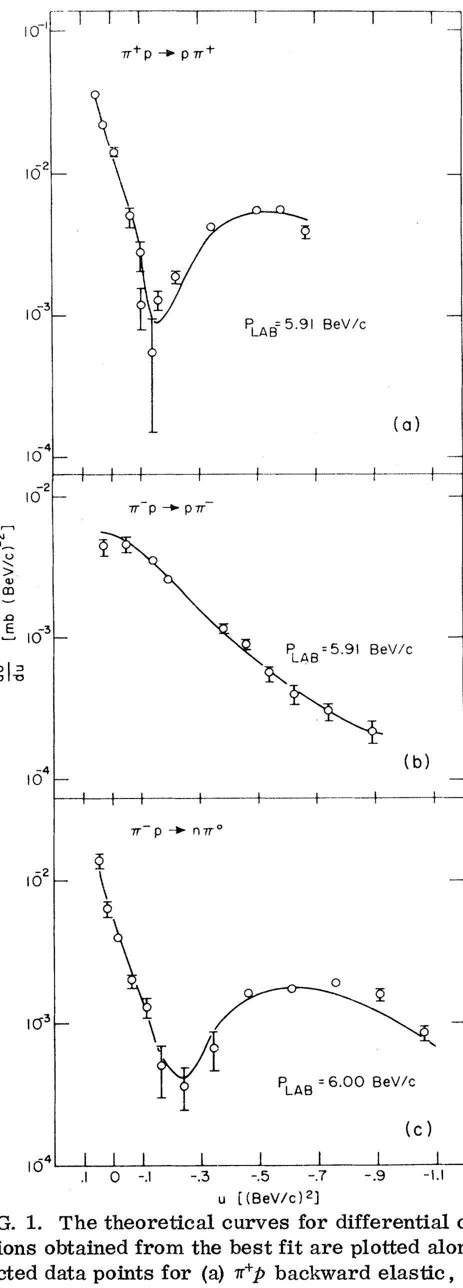

FIG. 1. The theoretical curves for differential cross sections obtained from the best fit are plotted along with selected data points for (a) π^+p backward elastic, (b) π^-p backward elastic, and (c) π^-p backward charge-exchange scattering. Data are from Ref. 7.

$$F^{\tau P}(W, s) = \gamma^{\tau P}(\alpha_1, W)\xi_\tau(\alpha_1)\nu^{\alpha_1 - 1/2} + \gamma^{\tau P}(\alpha_2, W)\xi_\tau(\alpha_2)\nu^{\alpha_2 - 1/2}, \quad (5)$$

with

$$\nu = (s-t)/2s_0, \quad s_0 = 1 \text{ BeV}^2, \quad (6)$$

$$\xi_\tau(\alpha) = (\alpha + \tfrac{1}{2})(\alpha + \tfrac{3}{2}) \frac{1 + \tau \exp[-i\pi(\alpha - \frac{1}{2})]}{\sin\pi(\alpha - \frac{1}{2})}. \quad (7)$$

The residues are parametrized as follows:

$$\gamma^{\tau P}(\alpha, W) = g_0(1 + g_1 W + g_2\alpha + g_3\alpha W)e^{h_1 W^2}. \quad (8)$$

The residues here differ from those in Ref. 1 by the elimination of the scaling term, $e^{h_0\alpha}$, which seems to play a nonessential role in the fits.

The trajectories and residues for $N_\alpha(\tau = +1, P = +1)$, $N_\gamma(\tau = -1, P = -1)$ and $\Delta_\delta(\tau = -1, P = +1)$ exchange are parametrized according to Eqs. (4) and (8). There are ten parameters for each trajectory-residue combination.

Fits to the differential cross section data[7] are shown in Fig. 1. They are in good agreement with the data, although there is slight disagreement between theory and experiment for $\pi^- p$ elastic scattering near $u = 0$.

The recent measurements of elastic polarization are compared with our model in Fig. 2. The agreement is very good and is consistent with the experimental error of the measurements.

In Table I we have given the parameter values for the best fit in the model. As before, each trajectory has a steep and flat branch, and MacDowell partners are avoided since the steep trajectories are on the unphysical sheet for $W < 0$.

We have shown that the CRP model is consistent with the latest πN backward scattering data and have determined the parameter values in the model.

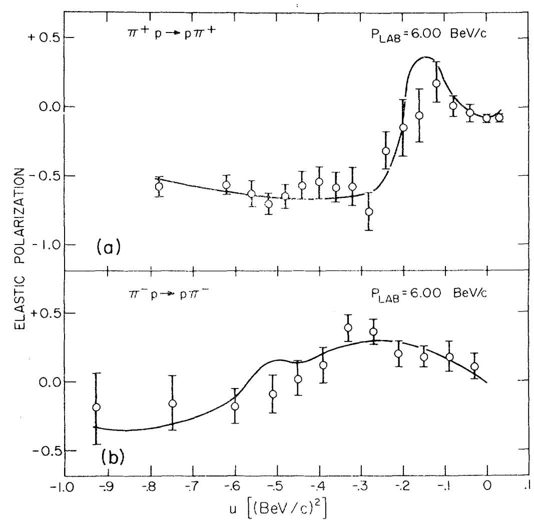

FIG. 2. Fits to the elastic polarization data in the backward direction at $P_{\text{Lab}} = 6$ BeV/c for (a) $\pi^+ p \to p\pi^+$ and (b) $\pi^- p \to p\pi^-$. Data are from Refs. 4 and 5.

TABLE I. Parameter values for the best fit.

Parameter	N_α	N_γ	Δ_δ
a	−0.41	−0.40	−0.02
b (BeV^{-1})	−0.04	0.01	−0.01
c (BeV^{-2})	−0.47	−0.23	0.01
d (BeV^{-1})	0.76	0.58	0.49
α_c	−0.43	−0.41	−0.15
g_0 (mb BeV)	166	80.7	−0.033
g_1 (BeV^{-1})	0.43	−0.87	260
g_2	2.70	2.10	261
g_3 (BeV^{-1})	1.70	−1.85	575
h_1 (BeV^{-2})	3.38	−0.17	1.54

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