CRITIQUE OF REGGE-POLES INTERPRETATION OF BACKWARD π^-p ELASTIC SCATTERING*

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In recent work, fits to certain elastic pion-nucleon data were obtained by adding a resonance amplitude and Regge-trajectory exchange amplitude. We show that the s-channel resonance amplitude considered in this recent work is, by itself, satisfactory to explain the backward π^-p scattering; i.e., it is shown that the need for a baryon-trajectory exchange amplitude is not established.

Recent papers by Barger and Cline[1,2] have suggested the successful application of Regge poles to the experimental data of Kormanyos et al.[3] on elastic π^-p scattering at $\cos\theta^* = -1$ in the momentum range 1.5 to 5.0 BeV/c, where the scattering amplitude is taken to consist of two terms: one associated with an exchange of a baryon trajectory (in the u channel) and the other the sum of resonance contributions in the direct channel (the s channel). The sensitivity of the results to the parameters governing the baryon-exchange trajectory amplitude and resonances in the direct channel has been investigated.

The direct channel s is $\pi^- + p \to \pi^- + p$, so that in going to the u channel one considers $\pi^+ + p \to \pi^+ + p$. The exchanged trajectory is due to the resonances of the system $\pi^+ + p \to \pi^+ + p$. The resonances of the system $\pi^+ + p \to \pi^+ + p$ are the Δ_δ, $I=\frac{3}{2}$, $P=+$, and therefore it is this trajectory that is considered. The form of this trajectory is taken to be[2]

$$\mathrm{Re}\,\alpha = 0.15 + 0.90u.$$

The direct channel resonances of the π^-p system which are considered are tabulated in Table I. In Table I there are shown the resonance parameters used in Ref. 1, as well as the set of parameters used in a fresh analysis here.

Results and conclusions.— The theoretical angular distributions[2] show the backward peak, but otherwise the quantitative agreement with the data[4] is very poor away from 180°. These curves are calculated using the Regge exchange amplitude and the resonance amplitudes.

With this prescription, fixing $\gamma(\sqrt{u})$ and s_0 to be constants, one does not fit the angular distribution quantitatively. Given a certain angular distribution at a fixed s, one can get a better fit by making the residue function γ

Table I. Parameters used for the s-channel resonances. These parameters were used to evaluate the resonance amplitudes discussed in the text: The resonance amplitude associated with Ref. 1 was calculated using the values which are not underlined (where more than one value is given, the parenthetical value was used). The pure resonance cross section is calculated with the same parameters except that underlined values are used where given.

Resonance (mass in MeV)		Spin-parity (J^P)	Width (BeV)		(X_I)	
$\Delta_\delta(1236)$		$3/2^+$	0.12		1.0	1.0
$\Delta_\delta(1929)$		$7/2^+$	0.17		0.35-0.50(0.46)	0.46
$\Delta_\delta(2452)$	2410	$11/2^+$	0.28	0.35	0.12	0.163
$\Delta_\delta(2840)$		$15/2^+$	0.40		0.05	0.061
$\Delta_\delta(3220)$		$19/2^+$	0.44		0.01-0.02(0.017)	0.025
$N_\gamma(1512)$		$3/2^-$	0.12		0.60	0.60
$N_\gamma(2190)$		$7/2^-$	0.24		0.20	0.20
$N_\gamma(2640)$		$11/2^-$	0.42	0.35	0.05	0.040
$N_\gamma(3020)$		$15/2^-$	0.40		0.015	0.002
$N_\gamma(3350)$		$19/2^-$	0.10		0.003-0.01(0.003)	0.003
$N_\alpha(938)$		$1/2^+$	...		...	
$N_\alpha(1688)$		$5/2^+$	0.10		0.60	0.60
$N_\alpha(2200)$		$9/2^+$	0.24		0.07	0.083
$N_\alpha(2610)$		$13/2^+$	0.42	0.32	0.02	0.035
$N_\alpha(2970)$		$17/2^+$	...		...	...

a function of u such as suggested by Chiu[5]:

$$\gamma(\sqrt{u}) = Ce^{au + bu^2}.$$

With the resonances of Ref. 1 and this form of γ, one may fit a given distribution, but this would be done at the expense of making the Regge amplitude dominate at all angles in the distribution. This would cause qualitative disagreement with the existing angular distributions at other energies.

We will show in what follows that the established success of the Regge background in fitting the $(d\sigma/d\Omega)_{180°}$ data of Kormanyos et al.[3] (especially the big dip at 2190 MeV) is not a sufficient condition for establishing the magnitude of the Regge amplitude.

The point of this Letter is to demonstrate this argument with a quantitative fit to the data of Kormanyos et al.,[3] using resonance amplitudes only. This will be called the "pure resonance cross section." The resonances considered to illustrate this point were arbitrarily chosen to be exactly those of Ref. 1, but with very small modifications as shown in Table I. The fit to the 180° data, Fig. 1, is as excellent as in Ref. 1. Indeed, there was little difficulty fitting the data using various assumptions about the resonance amplitude. The result is not so surprising considering that the 180° cross section due to the trajectory exchange above is small compared with the data in much of the momentum range. (The dashed curve shows the cross section due to the resonance amplitude above using the parameters of Ref. 1. One can see that the structure observed experimentally is already present.) The background total cross section (after subtraction of the resonance cross section) is shown in Fig. 2. The smoothness demonstrates that the modified resonance parameters are quite consistent with the bumps seen in the total cross section of Citron et al.[6] With the parameters of the present analysis, the calculated cross section at 8 BeV/c is lower than the data.[7] It is felt that this data point can be fitted in a number of ways such as by readjusting the parameters of the higher mass resonances or adding even more resonances.

The agreement between this theory and the angular distributions away from 180° is comparable with that obtained with the inclusion of the Regge exchange amplitude.[2] It is not easy to obtain even a fair fit to this data with or without the exchange amplitude, indicating,

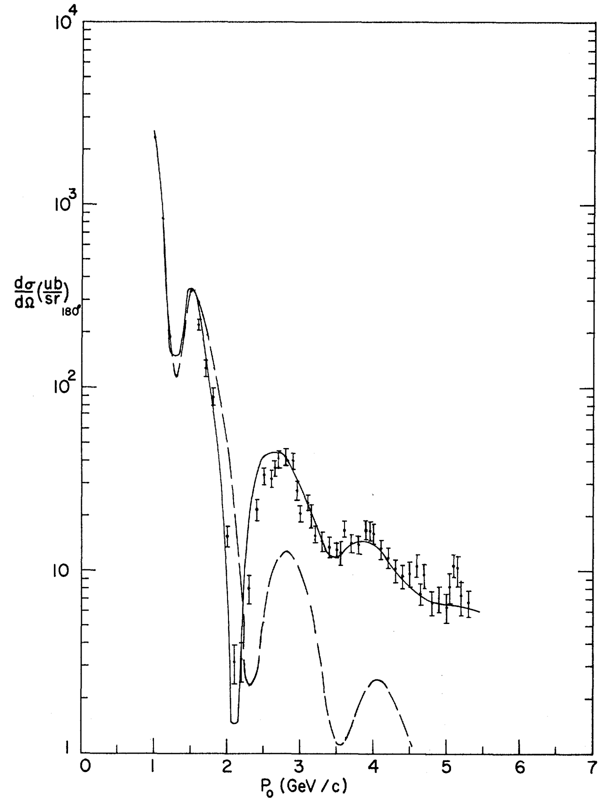

FIG. 1. The π^--p 180° differential cross section. The experimental points are from Ref. 3. The solid curve is the pure resonance cross section. The dashed curve is a resonance cross section calculated using the parameters of Ref. 1 (not underlined) as given in Table I.

perhaps the existence of more s-channel resonances or of other contributions. One can question whether the resonances which should finally be considered are, as yet, well established. It is found that almost any set of resonances will provide a backward peak.[8] The angular distribution of 180° is quite sensitive to certain resonances. For a very small deviation from $\cos\theta^* = -1$, one sees that the spin-flip amplitude becomes quite large, so that given a certain resonance of small elasticity, one might not see its effect in terms of structure at $\cos\theta^* = -1$; however, its effect might be very large just a little off $\cos\theta^* = -1$.

Merely by adjusting slightly the parameters of an a priori given list of resonances, we obtain fits which are as successful as fits obtained with the added exchange trajectory amplitude. It must be concluded that the parameters of this exchange amplitude are not well established. Even the existence of the exchange amplitude

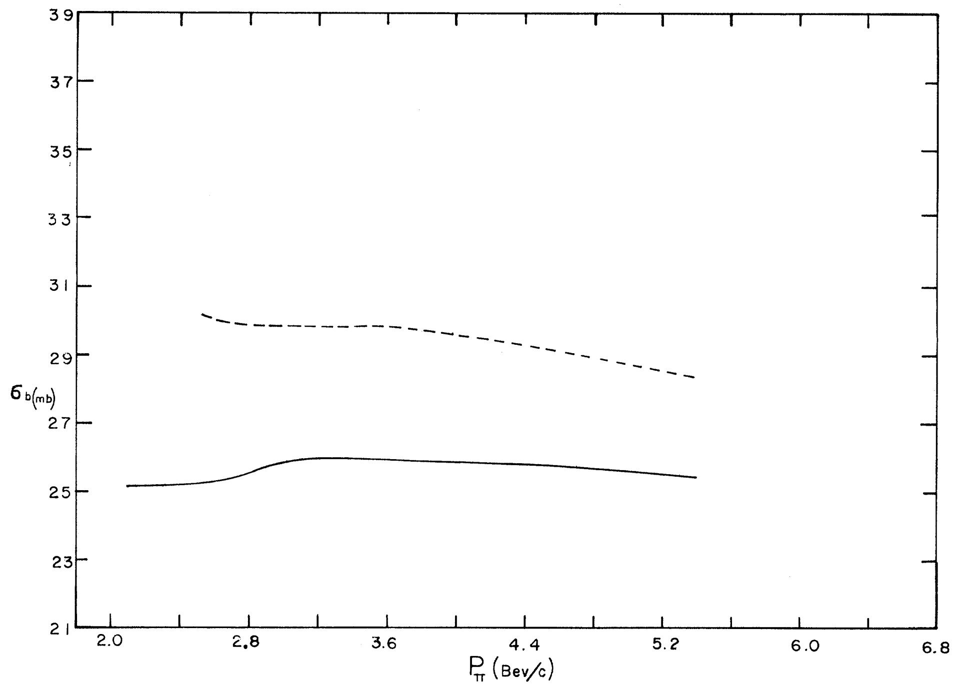

FIG. 2. The background total cross section (after subtraction of the resonance cross section calculated from the underlined parameters of Table I). The solid line is that of $\pi^+ + p \rightarrow \pi^+ + p$ and the dashed line is that of $\pi^- + p \rightarrow \pi^- + p$ (data from Ref. 6).

as distinct from the direct channel resonance amplitude is not established.

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