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Dual Absorptive Model and π^-p Backward Elastic Scattering

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Abstract

The dual absorptive model is used to explain the structure of the differential cross section for π^-p backward elastic scattering at incident pion momenta of 8 and 16 GeV/c.

Several years ago many attempts were made to measure the differential cross section for π^-p elastic scattering in the backward direction (e.g. Orear *et al.* 1966, 1968*a*, 1968*b*; Ashmore *et al.* 1967, 1968). Owen *et al.* (1969) succeeded in making a scattering cross section measurement in the angular region near 180° at incident pion momenta p_{L} from 5·9 to 16·25 GeV/c and up to crossed momentum transfers u of about -2 (GeV/c)^2. At fixed momentum transfer, all cross sections when expressed as $\mathrm{d}\sigma/\mathrm{d}u$ appeared to be decreasing with increasing energy. However, the data reported by Owen *et al.* were averaged over the bin widths, sometimes as large as $\Delta u = 0{\cdot}530$ (GeV/c)^2. More precise measurements of the differential cross section for backward elastic scattering were made by Anderson *et al.* (1968) at p_{L} values of 8 and 16 GeV/c with the squared momentum transfer $-u$ in the range $0{\cdot}095 \leqslant |u| \leqslant 0{\cdot}396$ (GeV/c)^2 and $0{\cdot}095 \leqslant |u| \leqslant 0{\cdot}730$ (GeV/c)^2 respectively. Theoretical attempts to fit these data in terms of Regge poles (Barger and Cline 1967*a*, 1967*b*) and quark models (Watson 1967) and to systematize the energy dependence of the differential cross section for this reaction have emphasized the need for more accurate data at high pion energies.

In this note we attempt to explain, on the basis of the dual absorptive model, the more accurately measured cross section data of Anderson *et al.* (1968) for π^-p backward elastic scattering. Unfortunately, polarization data for this process with incident pion momenta $p_{\mathrm{L}} \geqslant 8$ GeV/c are not available at present. However, we show here that without introducing any additional parameters the polarization can be predicted at higher energies for $-u = 0{\cdot}4$ (GeV/c)^2.

The dual absorptive model proposed by Harari (1971*a*, 1971*b*) has had remarkable success in predicting the dip structure in the differential cross section for several forward hadronic processes. Although the model was originally aimed at explaining these processes, Aye (1972) has shown that it can be equally applied to pion–nucleon backward scattering. The prescription for the model in this case has been given by Rafique *et al.* (1974).

For πN backward amplitudes, Aye (1972) has shown that, according to the above model, with a total s-channel helicity flip of $\Delta\lambda = 0$ there is a strong cut contribution for Δ exchange, while a $\Delta\lambda = 1$ amplitude has a strong cut contribution for N exchange. Since for the process $\pi^- p \rightarrow \pi^- p$ the exchange trajectory Δ_δ is odd, the u-channel description of $f^s_{\Delta\lambda}(s,u)$, the s-channel hadronic amplitude, is given by

$$\mathrm{Im} f^s_{\Delta\lambda=0}(s,u) = \hat{J}_0(r\sqrt{-u}), \qquad \mathrm{Re} f^s_{\Delta\lambda=0}(s,u) = K;$$
$$\mathrm{Im} f^s_{\Delta\lambda=1}(s,u) = -\hat{J}_1(r\sqrt{-u}), \quad \mathrm{Re} f^s_{\Delta\lambda=1}(s,u) = -\hat{J}_1(r\sqrt{u})\tan\tfrac{1}{2}\pi\{\alpha(u)-\tfrac{1}{2}\}.$$

The total scattering amplitudes f_0 and f_1 for the reaction are then

$$f_0 = [K + \mathrm{i}\,\gamma_0(u)\,\hat{J}_0(r\sqrt{-u})]s^{\alpha(u)},$$
$$f_1 = -\gamma_1(u)\,\hat{J}_1(r\sqrt{-u})\,[\tan\tfrac{1}{2}\pi\{\alpha(u)-\tfrac{1}{2}\} + \mathrm{i}]s^{\alpha(u)},$$

and the differential cross section is given by

$$\mathrm{d}\sigma/\mathrm{d}u = (64\pi s p^2)^{-1}\{|f_0|^2 + |f_1|^2\}.$$

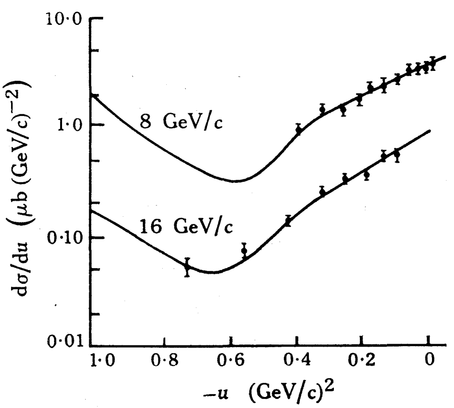

Fig. 1. Differential cross sections $\mathrm{d}\sigma/\mathrm{d}u$ for $\pi^- p$ backward elastic scattering at incident pion momenta of 8 and 16 GeV/c. The present theoretical predictions (curves) from the dual absorptive model are compared here with the experimental data of Anderson *et al.* (1968).

We have obtained a very good fit with the experimental data by assuming that the real part K of the scattering amplitude f_0 may be neglected in comparison with the imaginary part and choosing the following values for the parameters:

$$\gamma_0(u) = 269\exp(-2\cdot25\,u), \qquad \gamma_1(u) = 318\exp(-3\cdot5\,u)\cos\tfrac{1}{2}\pi\{\alpha(u)-\tfrac{1}{2}\}$$

and

$$\alpha(u) = -0\cdot1 + u.$$

Our value for $\alpha(u)$ is consistent with the doubly charged baryon exchange trajectory Δ_δ given by Anderson *et al.* (1968). The resulting fit to the experimental data for incident pion momenta of 8 and 16 GeV/c up to $-u = 1\cdot0\,(\mathrm{GeV}/c)^2$ is shown in Fig. 1. It is to be noted that the present results for high values of $-u$ do not agree with previous predictions (Barger and Cline 1968; Shih 1969; Kelly *et al.* 1970), and only experimental measurements at higher energies will decide on the relative merits of the various theoretical models.

The polarization P for the process is given by the formula

$$P = 2\,\mathrm{Im}(f_1 f_0^*)/(|f_0|^2 + |f_1|^2).$$

Since we are applying our model to pion momenta greater than 8 GeV/c and there are no comparable experimental data available as yet, we can only predict the polarization at higher energies. Unfortunately, the presence of the unknown parameter K in the expression for f_0 restricts us even in this regard. However, the term containing K vanishes at $u = -0 \cdot 4$ and the predicted values of the corresponding polarization at energies of 8, 16 and 32 GeV are $0 \cdot 75$, $0 \cdot 90$ and $0 \cdot 70$ respectively.

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