

## pp Elastic Scattering and the Pomeron Periphery

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### Abstract

It is shown that, in pp elastic scattering at ISR (intersecting storage ring) energies, a dip at  $t \approx -1.3 (\text{GeV}/c)^2$  and a bump at  $t \approx -2.0 (\text{GeV}/c)^2$  in the differential cross section, as well as a break at  $t \approx -0.1 (\text{GeV}/c)^2$  in the slope parameter, can be explained by a peripheral pomeron.

### Introduction

Since the first proposal of the dual absorptive model (DAM) by Harari (1970, 1971), many authors have used it to analyse successfully hadron-hadron and photo-production reactions. The essential assumption of this model is that the imaginary parts of the scattering amplitudes corresponding to resonances are peripheral with an interaction radius of about 1 fermi (Harari 1970) while those which correspond to the background integral are central. Recently it has been suggested (Barger *et al.* 1972a; Martin and Stevens 1973; Minami and Terada 1973) that, contrary to the conclusions of the DAM, the tensor-exchange amplitudes may have non-peripheral structure in spite of the peripheral structure of the vector-exchange amplitude. A two-component structure of the pomeron has been proposed by Barger *et al.* (1972b) to give a quantitative explanation of the break at  $-t = 0.1 (\text{GeV}/c)^2$  found in the pp elastic slope parameter in intersecting storage ring (ISR) experiments. However, those authors have confined their analysis of ISR results to  $-t \leq 0.4 (\text{GeV}/c)^2$ . Since the pomeron dominates the behaviour of elastic scattering at high energies, their simple model cannot explain the dip at  $-t \approx 1.3 (\text{GeV}/c)^2$  which persists even at the highest energies available from ISR. In this article we show that the dip and bump in the pp differential cross section as well as the break in the slope parameter at ISR energies can be explained by assuming that the pomeron is peripheral in nature.

In order to explain the dip structure in the differential cross section, Harari (1970, 1971) extensively appealed to the vanishing of a particular  $J_{\Delta\lambda}(r\sqrt{-t})$  which is supposed to dominate the corresponding process. No doubt such an assumption about the dominance of a particular  $J_{\Delta\lambda}(r\sqrt{-t})$  does lead to the envisaged dip, but the same dominance also implies dips for other values of  $-t$  which are not observed experimentally. As an example, for all the reactions for which the crossing is odd and s-channel ( $\Delta\lambda = 1$ ) helicity amplitude dominates, the model gives a dip at  $t = -0.6 (\text{GeV}/c)^2$  in accordance with experiment (Harari and Schwimmer 1971), but also predicts a dip at  $t = 0$  which is clearly inconsistent with the experimental data. This difficulty can be overcome if we do not, *a priori*, make any assumption about the dominance of amplitudes pertaining to a particular helicity flip.

The strength of the helicity amplitudes should be determined from the fitting of experimental cross section data over a wide range of squared four-momentum transfer.

There has also recently been considerable discussion on the consistency of an intercept of one pomeron pole with unitarity. It has been claimed by Brower and Weis (1972) that such a pole should decouple from elastic processes at  $t = 0$ . These ideas have been used to explain the following features of recent data for pp scattering at ISR energies (Amaldi *et al.* 1972, 1973; Barbiellini *et al.* 1972; Amendolia *et al.* 1973):

- (1) a pronounced dip-bump structure; the dip at  $t \approx -1.3 (\text{GeV}/c)^2$  stays fixed with energy;
- (2) at a fixed energy, the slope of the diffraction peak shows a break at  $t = -0.1 (\text{GeV}/c)^2$ .

Ng and Sukhatme (1973) and Pajares and Schiff (1973) have explained one or more characteristics of high energy elastic pp scattering by employing Gribov's (1967) reggeon calculus (Gribov and Migdal 1968*a*, 1968*b*; Baker 1973). However, the DAM can also be used to explain these characteristics provided that the pomeron is taken to be peripheral.

### Parameterization and Comparison with Data

The number of independent helicity amplitudes for pp elastic scattering is five. In general more than one helicity amplitude correspond to the same value of  $\Delta_\lambda$ ; such amplitudes then differ only in their residue functions. At high energy, as the scattering is dominated by the exchange of a pomeron trajectory, the helicity amplitudes  $f_{\Delta_\lambda}$  will be of the form

$$f_{\Delta_\lambda} = B_{\Delta_\lambda}(t) J_{\Delta_\lambda}(r\sqrt{(-t)}) (s/s_0)^{\alpha(t)} \{-\cot(\frac{1}{2}\pi\alpha(t)) + i\},$$

where  $\alpha$  is the pomeron trajectory. The contribution to the differential cross section may therefore be written as

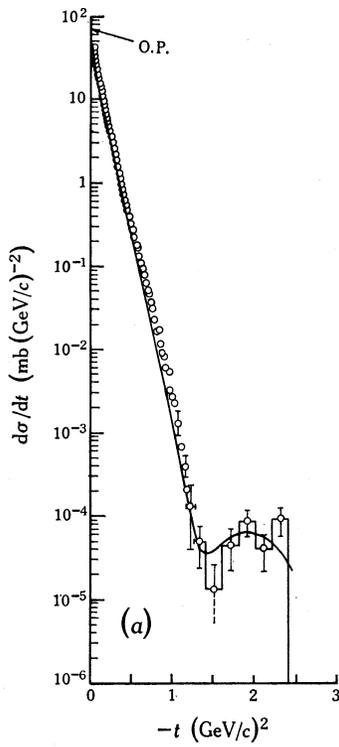
$$\begin{aligned} d\sigma/dt = & \{a(t)J_0^2(r\sqrt{(-t)}) + b(t)J_0^2(r\sqrt{(-t)}) + c(t)J_1^2(r\sqrt{(-t)}) \\ & + f(t)J_1^2(r\sqrt{(-t)}) + g(t)J_2^2(r\sqrt{(-t)})\} q^{-2} s^{2\alpha(t)-1} \text{cosec}^2(\frac{1}{2}\pi\alpha(t)). \end{aligned}$$

We have found that a very good fit to the experimental data is obtained by choosing:

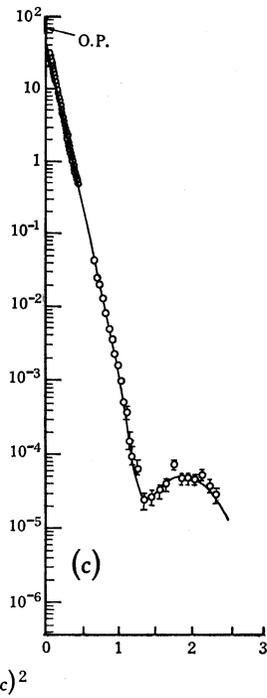
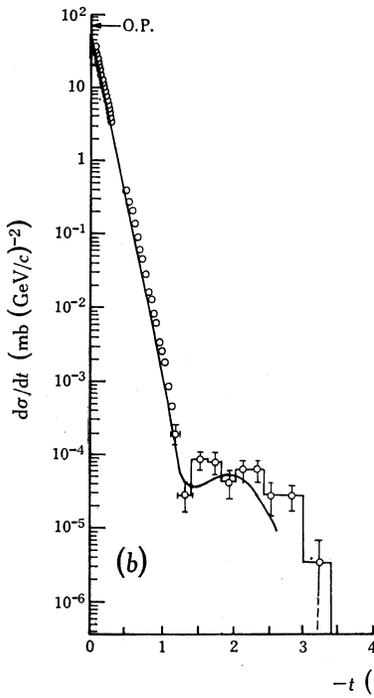
$$\begin{aligned} a(t) &= 0.0006, & b(t) &= 18 e^{8t}, & c(t) &= 2 e^{7t}, \\ f(t) &= 0, & g(t) &= 120 e^{13t}, & \alpha(t) &= 1 + 0.05 t, \end{aligned}$$

where the units of the parameters  $a$ ,  $b$ ,  $c$  and  $g$  are  $\text{mb}^\frac{1}{2} \text{GeV}$ .

Fig. 1 shows the differential cross section  $d\sigma/dt$  plotted against  $-t$  for  $s = 949$ , 2016 and 2809  $(\text{GeV}/c)^2$  and for  $0 \leq -t \leq 2.5 (\text{GeV}/c)^2$ , the region in which the model can be considered to be effective. The curves, which represent the theoretical predictions from the model, show that the agreement with experiment is quite good.



**Fig. 1.** Comparison of experimental data for the differential cross section for pp elastic scattering with the theoretical predictions (curves) from the model described in the text:  
 (a)  $s = 949 \text{ (GeV/c)}^2$ ,  
 (b)  $s = 2016 \text{ (GeV/c)}^2$ ,  
 (c)  $s = 2809 \text{ (GeV/c)}^2$ .  
 The optical point (O.P.) is indicated in each case.



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