**IMPACT PICTURE IN THE COULOMB INTERFERENCE
REGION AT HIGH ENERGIES**

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Impact Picture in the Coulomb Interference Region at High Energies

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Abstract

We present the predictions on $p\bar{p}$ elastic differential cross sections in the Coulomb interference region for energies 0.546 to 2.0 TeV on the basis of the impact picture.

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Seventeen years ago, it was predicted on the basis of quantum gauge field theory that, for hadron-hadron scattering at high energies, both the total cross section σ_{tot} and the ratio of the integrated elastic cross section σ_{el} to the total cross section must increase at high energies [1]. By incorporating this rising total cross section obtained from field theory into the optical model, some phenomenological data analysis has been carried out beginning in the early seventies [2,3]. The predictions of this impact-picture phenomenology have been repeatedly verified by experiments [4], most recently from the data of the CERN $p\bar{p}$ collider.

In this paper we concentrate on the Coulomb interference region for $p\bar{p}$ elastic scattering in the energy range of the CERN collider and the Fermilab Tevatron. The predictions of the impact picture beyond the Coulomb interference region have been given recently [5]. The $p\bar{p}$ elastic scattering is described by the following amplitude

$$a(s, t) = a^N(s, t) + a^C(t) \quad (1)$$

where $a^N(s, t)$ is the hadronic amplitude and $a^C(t)$ is the Coulomb amplitude. The Coulomb amplitude is of course

$$a^C(t) = -2\alpha \frac{G^2(t)}{|t|} \exp[i\alpha\phi(t)] \quad (2)$$

where α is the fine structure constant, $\phi(t)$ is the West-Yennie phase [6] given by

$$\phi(t) = \ln(t_o/|t|) - \gamma \quad (3)$$

with $t_o = 0.08 \text{ GeV}^2$ and $\gamma = .577$ is the Euler constant. We use

$$G(t) = [(1 - t/m_1^2)(1 - t/m_2^2)]^{-1} \quad (4)$$

as the proton electromagnetic form factor. From the impact picture the hadronic amplitude is given by

$$a^N(s, t) = is \int_0^\infty J_0(b\sqrt{-t})(1 - e^{-\Omega_0(s, b)})db \quad (5)$$

where

$$\Omega_0(s, b) = S_0(s)F(b^2) + R_0(s, b) \quad (6)$$

with $R_0(s, b)$ being the Regge background which is negligible at the energies under consideration. With Regge background neglected, the $a^N(s, t)$ is the same for pp and $p\bar{p}$. The energy dependence is given by the crossing symmetric function

$$S_0(s) = s^c / (\ln s)^{c'} + u^c / (\ln u)^{c'} \quad (7)$$

which comes from the high energy behaviour of quantum field theory. In (7) u is the third Mandelstam variable. The t -dependence of $a^N(s, t)$ is controlled by $F(b^2)$ whose Fourier transform is taken to be [3]

$$\tilde{F}(t) = f[G(t)]^2[(a^2 + t)/(a^2 - t)] \quad (8)$$

The values of the parameters are [3]

$$\begin{array}{ll} c = 0.167 & c' = 0.748 \\ m_1 = 0.586 \text{ GeV} & m_2 = 1.704 \text{ GeV} \\ a = 1.953 \text{ GeV} & f = 7.115 \text{ GeV}^{-2} \end{array} \quad (9)$$

The predictions for the Tevatron are shown in fig. 1. Since the Tevatron was running at $\sqrt{s} = 1.8 \text{ TeV}$ we show in fig. 2 the predictions in the t -range up to 0.12 GeV^2 . It will be interesting to compare it with data from experiment E710.

At the CERN Collider the UA4 collaboration has obtained data at $\sqrt{s} = 546 \text{ GeV}$ in the Coulomb interference region. We show in fig. 3 the prediction at this energy together with the result without the Coulomb term. We understand that their data is in good agreement with this prediction. At some preliminary stage they quoted the value 0.24 ± 0.04 for

$$\rho = \frac{\text{Re } a^N(s, t=0)}{\text{Im } a^N(s, t=0)}$$

to be compared with our prediction $\rho = 0.13$ [3]. This discrepancy is due to the oversimplified form of $a^N(s, t)$ that was used in their data analysis.

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FIGURE CAPTIONS

- Fig. 1 $d\sigma/dt$ for $p\bar{p}$ elastic scattering in the Coulomb interference region at two energies of the Fermilab Tevatron.
- Fig. 2 $d\sigma/dt$ for $p\bar{p}$ elastic scattering at $\sqrt{s} = 1800$ GeV in the small t region.
- Fig. 3 $d\sigma/dt$ for $p\bar{p}$ elastic scattering at $\sqrt{s} = 546$ GeV (dashed curve is the pure hadronic cross section).

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Fig. 1

Fig. 2

Fig. 3