

REGGE THEORY FOR HIGH ENERGY PROTON – DEUTERON ELASTIC SCATTERING

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Abstract: The characteristics of proton-deuteron elastic scattering at ISR energies have been explained by using the Regge theory. The agreement between the experimental data available at $\sqrt{s} = 53$ and 63 GeV is very good.

Keywords: Proton-Deuteron elastic scattering, Regge theory, t-dependence.

INTRODUCTION

The differential cross section measurements of proton-deuteron (pd) elastic scattering at high energies were made by Goggi *et al.* [1978,1979] during 1978 and 1979. A comprehensive solution based on Regge theory [Collins 1977] has been given.

MATERIALS AND METHODS

Goggi *et al.* [1978, 1979] reported experimental results on proton-deuteron elastic scattering at high energies $\sqrt{s} = 53$ and 63 GeV, where s stands for the square of the CM energy. The data were obtained using the split field magnet detector at ISR. The data cover the single and multiple scattering regions over a wide interval of four-momentum transfer squared, $-t$. They observed clear evidence for a substantial t -dependent contribution of inelastic intermediate states in the multiple scattering regions as well as in single scattering. The t -dependence of the elastic differential cross section was measured in the range from $-t = 0.06$ to $1.65 (\text{GeV } c^{-1})^2$ at $\sqrt{s} = 53$ GeV and from $-t = 0.08$ to $1.85 (\text{GeV } c^{-1})^2$ at $\sqrt{s} = 63$ GeV. The exponential slopes below and above the interference region are about $30 (\text{GeV } c^{-1})^2$ and $5 (\text{GeV } c^{-1})^2$, respectively. The differential cross section measurements at $\sqrt{s} = 53$ and 63 GeV are shown in Figs. 1 and 2, respectively.

THEORETICAL MODELS

Attempts have been made to explain the proton-deuteron elastic scattering on the basis of Chou-Yang model and multiple-scattering theory. Parida and Patel [1981] have used the pristine Chou-Yang model [Chou and Yang 1968] to calculate the differential cross section in pd elastic scattering with a view to investigate whether dips and higher order maxima would appear at very high energies. For this purpose they have used the interpolating formulae for the proton and the deuteron form factors, which have exploited analyticity properties. Their calculations indicate that the Chou-Yang approximation to the differential cross section, with only the imaginary part of the scattering amplitude is

applicable in the diffraction peak region. Although the predictions have been made by Parida and Patel [1981] for the t values lying beyond the diffraction peak region, they do not agree with the large $-t$ measurements of Goggi *et al.* [1978, 1979].

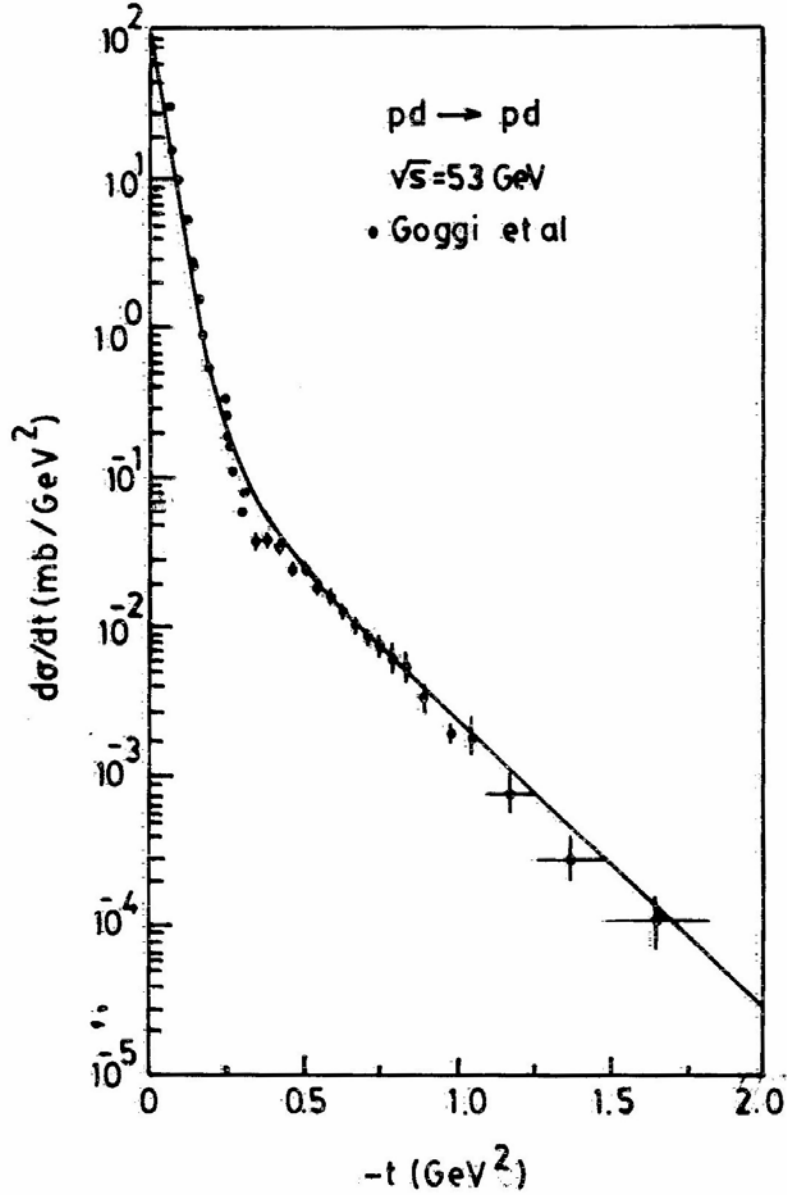


Fig. 1

Fig. 1: Theoretical results as compared to the experimental differential cross section [Goggi 1978, 1979] at $\sqrt{s} = 53$ GeV.

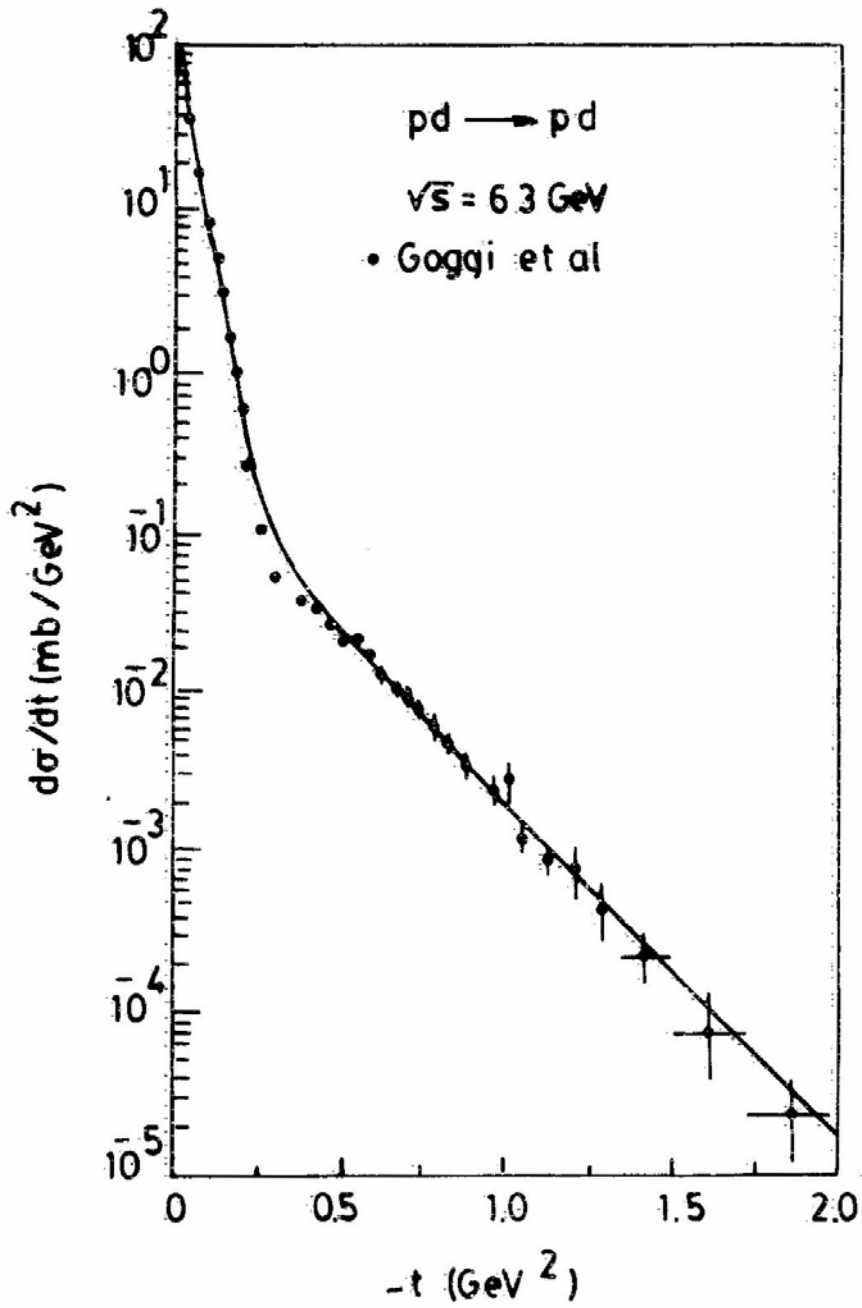


Fig.2

Fig. 2: Theoretical results as compared to the experimental differential cross section [Goggi 1978, 1979] at $\sqrt{s} = 6.3 \text{ GeV}$.

Braun [1988], using the Glauber theory including inelastic correction, has calculated the pd elastic differential cross section at high energy. The predictions have been made by using non-relativistic wave functions of the deuteron including D-wave in the electric and quadrupole form factors at $\sqrt{s} = 53$ and 63 GeV. The results agree very well with the experimental data but only up to $-t \approx 1 \text{ (GeV c}^{-1}\text{)}^2$ while the measurements have been made up to $-t \approx 2 \text{ (GeV c}^{-1}\text{)}^2$.

The generalized Chou-Yang model has also been used by Aleem *et al.* [1995] to fit the experimental differential cross section data for pd elastic scattering. Their results are in good agreement with the experimental measurements except in the vicinity of the shoulder where the difference is significant.

In this paper, we have used simple Regge theory to fit the experimental data at ISR energies $\sqrt{s} = 53$ and 63 GeV. The theory has already been used [Ali and Ali 2003] to explain the characteristics of various processes. We find that an excellent agreement in the entire measured $-t$ region is obtained at both the energies, by using a small number of total parameters as compared to other models.

According to this theory, the scattering occurs by the exchange of Regge and pomeron trajectories. No doubt at high energies the pomeron trajectory dominates the behaviour of the scattering amplitude and it is for this reason that we have assumed the exchange of only the pomeron trajectory at this energy. The differential cross section $d\sigma/dt$ and the total cross section σ_T are given by the relations:

$$\frac{d\sigma}{dt} = (1 / s^2) |T|^2 \text{ mb (GeV / c)}^{-2}$$

and

$$\sigma_T = (4\sqrt{\pi / s}) \sqrt{0.3895} \text{ Im } T(s, t = 0) \text{ mb}.$$

The last relation is obtained by virtue of the well-known optical theorem. We will assume that the real part of scattering amplitude is very small as compared to its imaginary part and therefore could be ignored.

The scattering amplitude in this theory is given by the expression:

$$T = F(t) \xi(t) s^{\alpha(t)}$$

where $F(t)$ is the residue function, $\xi(t)$ is the signature factor and $\alpha(t)$ is the pomeron trajectory.

CALCULATIONS AND DISCUSSION

The scattering amplitude in this theory has been taken as:

$$T = G(t) s^{\alpha(t)}, \quad \text{where } G(t) = F(t) \xi(t).$$

We have made the following choice of parameters to predict $d\sigma/dt$ for pd elastic scattering:

$$G(t) = A + B,$$

Where $A = 9.0 \exp(15.3 t)$ and $B = 0.4 \exp(1.5 t)$.

The pomeron trajectory has been taken as $\alpha = 1 + 0.05 t$.

The differential cross sections thus obtained for $\sqrt{s} = 53$ and 63 GeV are shown by curves in Figs. 1 and 2, respectively. Our results are in very good agreement with the available experimental data. The total cross section is predicted to be 42 mb. The slope parameters in different regions have also been computed for $\sqrt{s} = 53$ GeV and the results agree with the experimental data. Since the energy dependence in the Regge model is known, the model can be used to predict the differential and total cross sections and other characteristics of pd scattering at other values of high energy.

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