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DETERMINATION OF THE SLOPE OF THE POMERANCHUK FROM A
PHENOMENOLOGICAL "MULTI VENEZIANO" MODEL

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A B S T R A C T

We show how a simple inelastic model involving Regge trajectories except the Pommeranchuk can be used to calculate the slope of the Pommeranchuk. Application to the reaction $\pi N \rightarrow (n-1)\pi N$ gives a slope of 0.2.

In a previous note ¹⁾ we suggested a phenomenological amplitude to describe multi-particle production which included Regge trajectories in the relevant s and t channels. This model treated the Pomeron in no special way since it was exchanged in multi-Regge graphs just as the usual trajectories, ρ , Δ etc., were. Here we wish to explore the consequences of adopting a special role for the Pomeron. We shall assume it not to be a Regge trajectory in the normal sense but simply as a parametrization of the elastic amplitude in the small t region: i.e.,

$$\text{Im } T_{el.}(s, t) = F(t) s^{\alpha_P(t)-1} \quad (1)$$

Next we assume that elastic scattering in this region is just the shadow of inelastic scattering. Then we construct a simple phenomenological inelastic amplitude and study the behaviour of elastic scattering through the overlap function ²⁾. In particular we want to investigate the predictions of such a model for the shrinkage of the diffraction peak. Our aim is therefore to calculate the slope of the Pomeron "trajectory" from an inelastic model which involves only "proper" trajectories - i.e., those which have associated particles or resonances.

We suggest the following form for the inelastic amplitude which is the simplest phenomenological generalization of the Veneziano ³⁾ model:

$$A^{(n)} = \prod_{i=1}^{n-1} A_i$$

$$A_i = g_i \exp[B(t_{i-1} + t_{i+1})] \frac{\Gamma(\sigma_s - \alpha_s) \Gamma(\sigma_t - \alpha_t)}{\Gamma(\sigma_s - \alpha_s - \alpha_t)} \quad (2)$$

where $A^{(n)}$ is the amplitude for a multi-Regge graph for the process $a+b \rightarrow 1+2+\dots+n$. The variables s_i , t_i , etc., can be understood by representing A_i graphically (see Fig. 1).

The exponential dependence on t_{i-1} , t_{i+1} represents the off-shell nature of the scattering represented by Fig. 1. σ is the spin of the first resonance on the α trajectory. We wish to emphasize that this is a very crude application of Veneziano's amplitude to a many-particle process and should not be confused with those generalizations to five- and higher point functions derived in an exact manner⁴⁾. Nevertheless such a model can be justified by its ease of application and its consistency with experiment.

Consider the application of the amplitude (2) to the reactions $\pi N \rightarrow (n-1)\pi N$. In the relevant t channels we insert ρ , f , A_2 and nucleon trajectories, and in the s channels we put ρ , f (degenerate) and Δ , N (degenerate) with $\alpha = \frac{3}{2}$ as first pole. This last approximation implies that the D_{15} mass is at 1630 instead of 1680 but the importance of higher recurrences is reduced by choosing the imaginary of the trajectory to be

$$\text{Im} [\pi \alpha_s] = A \log \left(1 + \frac{s-s_0}{\alpha} \right) \quad (3)$$

with $\alpha = 1(\text{GeV})^2$. For ρ , f we take $A=0.7$; for Δ , N , $A=1.3$. The exponent B [of Eq. (2)] is taken to $1(\text{GeV})^{-2}$ leaving one parameter $g=g_B/g_m$ [as in Ref. 1] which we take equal to 0.2.

In Fig. 2 we illustrate examples of single- and two-particle distributions for the case of $n=5$, calculated using the above values of the parameters.

In order to calculate the shadow elastic scattering via the overlap function we shall assume that it is sufficient to calculate the function $F_N(s,t)$ only, where N is the average multiplicity. Later we shall justify such an assumption that we obtain the same t dependence as by calculating all multiplicities and weighting according to the partial cross-sections. Bartke and Czyzewski⁵⁾ calculate the cross-sections for $\pi N \rightarrow (n-1)\pi N$ at 4, 8 and 10 GeV using isospin statistical factors. From this we interpolate that $N=5$ is the average multiplicity at 7.8 GeV and $N=6$ that of 13.2 GeV.

If the elastic amplitude is parametrized by Eq. (1) then

$$\alpha_p(t) - 1 = \frac{\log [F_N(s_1, t) / F_N(s_2, t)]}{\log [s_1 / s_2]} \quad (4)$$

where we assume that $\alpha_p(0) = 1$ and we normalize $F_N(s, 0) = 1$.

We calculate $F_N(s, t)$ according to Eq. (6) of Ref. 1) and the integration is carried out numerically by FOWL, a Monte Carlo computation. It is regrettable that this technique implies that $F_N(s, t)$ can be calculated only within errors of about 10%.

Below we list the results.

t	$F_5(s, t)$ at 7.8 GeV	$F_6(s, t)$ at 13.2 GeV	error
0	1.000	1.000	
-0.1	0.531	0.520	~ 8%
-0.2	0.302	0.282	~10%
-0.3	0.172	0.163	~12%
-0.4	0.103	0.097	~15%
-0.5	0.069	0.068	~18%

$\alpha_p(t)$ is the calculated according to (4) and the corresponding results are shown in Fig. 3. If $\alpha_p(t)$ is of the form $a t + 1$, then we find the best fit for the slope is $a = 0.2 \pm 0.4$. This small slope is consistent with almost complete absence of shrinkage of the diffraction peak in πN scattering.

Our conclusion is, therefore, that in this "multi-Veneziano" model the Pomeron is not a Regge trajectory in the usual sense. It is simply a convenient way of parametrising diffraction scattering which is itself entirely the shadow of inelastic scattering.

We have also calculated several $F_n(s,t)$ for varying n , s according to this model. Within the errors of integration we found that up to about 14 GeV, the slope of the diffraction peak was almost entirely independent of n and s . This "universal" slope of $d\sigma/dt$ comes out to be 10.8 ± 1.2 which is somewhat steeper than the constant experimental value of about $9^{6)}$.

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FIGURE CAPTIONS

Figure 1 : Graphical representation of A_i .

Figure 2 : Distribution of $\cos \theta$ for proton and mass distributions for πp and $\pi \pi$ for the reaction $\pi^+ p \rightarrow 2 \pi^+ \pi^- \pi^0 p$ at 8 GeV ⁷⁾.

Figure 3 : Values of $\alpha_p(t)$ calculated from Eq. (4).

FIG.1

FIG. 2

FIG. 3