TRIPLE POMERON VERTEX, DUALITY AND DIFFRACTION DISSOCIATION *

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By invoking duality for the Reggeon-particle absorptive part, we relate the triple Reggeon coupling to the low missing mass spectrum in diffraction dissociation. Existing experimental data are analyzed and suggest that the triple Pomeron coupling is small.

Current interest in multiparticle production theory centers around the recently proposed limiting fragmentation [1] or scaling [2] hypothesis of Yang and collaborators and Feynman for the inclusive single particle spectrum. In this paper, we invoke the duality hypothesis of Harari [3] to propose a new Regge analysis for the single particle spectrum near the phase space boundary for diffraction dissociation. This analysis indicates indirectly that the triple Pomeron coupling is small.

We consider the process $a+b \to a+X$, where X represents a sum of produced particles which go unobserved for a given P_a, P_b and P_a'. See fig.1. The cross section for this process can be written as a function of

$$s = (P_a + P_b)^2$$

$$t = (P_a' - P_a)^2$$

$$M^2 = (P_a + P_b - P_a') = P_X^2 \qquad (1)$$

From the multi-Regge model [4] or Mueller's approach [5], the single particle spectrum in the region of fixed small t, large M^2 and large s/M^2 is given by,

$$d\sigma/dt\,dM^2 = \frac{\beta(t)}{s^2}\left(\frac{s}{M^2}\right)^{2\alpha(t)} (M^2)^{\tilde{\alpha}(0)} \qquad (2)$$

corresponding to the diagram in fig. 1b. Here, $\alpha(t)$ is a Reggeon exchange at the $a\bar{a}$ vertex and scatters with particle b to produce the unobservable states X. $\tilde{\alpha}(0)$ is the intercept of the leading Regge trajectory coupling to the $b\bar{b}$ channel at zero momentum transfer and was built up from the unitarity summation over the unobserved states in the process $\alpha(t) + b \to X$ depicted in fig. 1a.

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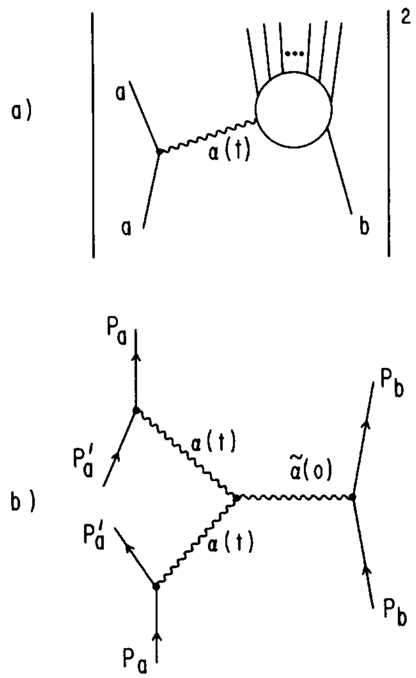

fig.1. a) Matrix element squared for diffractive dissociation.
b) Kinematical variables and the triple Reggeon vertex.

It controls the asymptotic behavior of the Reggeon $(\alpha(t))$ - particle (b) forward absorptive part at large M^2. $\beta(t)$ measures the strength of the triple Reggeon vertex which governs the dynamics in this kinematical regime. For diffraction dissociation at large M^2 and s/M^2, $\alpha(t)$ and $\tilde{\alpha}(0)$ should be the Pomeron trajectory, $\alpha_P(t)$, and intercept, $\alpha_P(0)$, respectively. Therefore, diffraction dissociation into large M^2 is a measure of the strength of the triple Pomeron coupling [6, 7

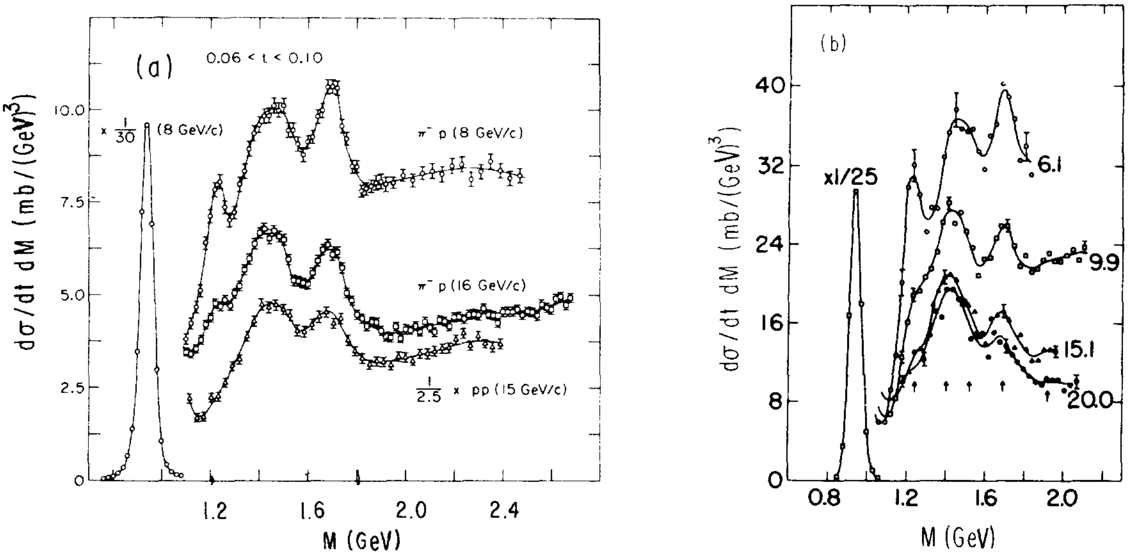

Fig.2. Missing mass spectrum for the process a) $\pi^- + p \to \pi^- + X$ at 8 and 16 GeV/c for $0.06 < t < 0.10$ GeV^2 b) $p + p \to p + X$ at 6.1, 9.9, 15.1 and 20.0 GeV/c for $t = 0.042$ GeV^2.

It has been found by Harari [3], that within the context of elastic scattering, there is a correspondence or duality between low energy direct channel resonances on the one hand, and crossed channel Regge exchanges on the other. In these considerations, the Pomeron exchange component was found to be dual to the low energy background, or non-resonant structure. This duality finds quantitative meaning within the framework of Finite Energy Sum Rules [8] and Schmid Circles [9].

Although no formal machinery exists with which to carry it over, we invoke this same hypothesis for the Reggeon-particle absorptive part in order to make qualitative statements about diffraction dissociation at low values of M^2. In this domain, the single particle spectrum can be seen from fig. 2 [10] to be a series of resonance bumps (N*'s) superposed on a smooth non-resonant background, reminiscent of the behavior of low energy cross sections in non-exotic channels. We propose that in the spirit of duality, the low M^2 background component of the missing mass spectrum is dual to the Pomeron exchange contribution in the Reggeon-particle absorptive part. Similarly, we take the resonances to be dual to the P', and other Regge exchanges. Once this hypothesis is adopted, we can investigate qualitatively the nature of the triple Reggeon couplings which control diffraction dissociation at large M^2 from an analysis of the data at low and intermediate values of M^2.

From the diffraction dissociation data of Anderson et al. [10, 11] shown in fig. 2, it has been found that the cross section, $d\sigma/dt dM^2$ for the production of discrete resonance states N*(1400, 1520, 1688) are roughly constant as a function of s [10, fig. 4]. This indicates that for these processes, $\alpha(t)$ is the Pomeranchuk trajectory. From the duality hypothesis, we can therefore infer that the P-P-P' triple Reggeon coupling is finite. On the other hand, we observe from fig. 2 that the non-resonant background for a given M^2 at small values of t, falls roughly with energy as s^{-1}. From eq. (2), this indicates that the effective trajectory, $\alpha(t)$, responsible for the production of the background component is $\alpha(t) \approx 0.5$. From duality this implies that the triple Pomeron coupling is small, and that the dominant contribution is from the M-M-P triple Reggeon vertex, where M is some high ranking meson Regge pole (P', ω, ρ...), with trajectory $\alpha_M(t) \approx 0.5$.

To illustrate this behavior, we have plotted in fig. 3a and 3b the cross sections of figs. 2a and 2b for given M^2 intervals as a function of s^{-1}. A straight line on this plot signifies that the relevant exchanges present are $\alpha_P(t) \approx 1$ and $\alpha_M(t) \approx 0.5$. For mass intervals which include one of the prominent N* resonances (broken curves in fig. 3a and 3b), the y intercepts of the curves are positive indicating that the cross section to produce these discrete resonance states persist as $s \to \infty$. However, part of this asymp

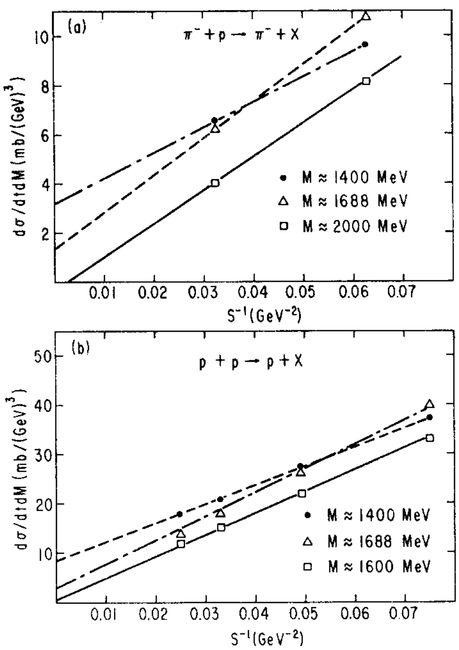

Fig.3. Cross sections for given mass bands from a) 2a and b) fig.2b respectively.

totic cross section may arise from the presence of a triple Pomeron coupling. To investigate this possibility, the solid curves in fig. 3a and 3b plot the cross section for mass intervals which exclude any of the N* resonances. In comparison, the y intercepts of these curves are close to zero or slightly negative indicating that the triple Pomeron coupling is very weak if it exists at all *.

This result was not unexpected. In terms of Feynman's scaled variable, $x = 2P_{\parallel}^{\text{c.m.}}/s^{\frac{1}{2}}$, the contribution of the triple Pomeron coupling to the single particle spectrum near the phase space boundary, $x \approx 1 - M^2/s \approx 1$, is from eq. (2).

$$\frac{1}{\sigma_{tot}} \mathrm{d}\sigma/\mathrm{d}x\mathrm{d}t = \beta_{PPP}(t)\,(1-x)^{\alpha_P(0) - 2\alpha_P(t)} \qquad (3)$$

For $\alpha_P(0) \approx 1$, the behavior of the spectrum is singular at the boundary. If $\beta_{PPP}(t)$ is finite for arbitrarily small $1 - \alpha_P(0)$, eq. (3) will be in conflict with unitarity, since the integrated probability for the diffraction dissociation will exceed the total cross section ‡. Therefore the smallness of $\beta_{PPP}(t)$ is a measure of the proximity of $\alpha_P(0)$ to 1 ⨥.

Consequently, for $t \approx 0$, the dominant behavior of the background contribution to the single particle spectrum is a fall off as $s^{2\alpha_M(t)-2} \approx s^{-1}$ for a given interval of M^2. For a given value of s, it behaves as $(M^2)^{\alpha_P(0) - 2\alpha_M(t)} \approx$ constant as a function of missing mass. The real importance of the background lies in the fact that its region of extent in M^2 increases linearly with s. Its contribution to $\mathrm{d}\sigma/\mathrm{d}t\mathrm{d}M^2$ is like a rectangle whose height decreases as $\sim s^{-1}$ while its length increases as s such that the total area remains constant. It therefore contributes a finite fraction of the total cross section as $s \to \infty$ and is worthy of more detailed investigation.

In conclusion, we stress the importance of a more thorough study of the background component of the missing mass spectrum in diffraction dissociation. An analysis along the lines suggested in this paper will shed much light on the dynamics of diffraction dissociation into large masses and give needed insight into the nature of the Pomeranchuk singularity.

This work was begun in collaboration with Dennis Silverman. To him and William Frazer, we are indebted for many interesting discussions.

After this work was completed, the authors were informed by J. M. Wang and L. L. Wang that they have performed an analysis along the same lines, and have come to roughly similar conclusions.

* A theory of multiparticle production based on the vanishing of the triple Pomeron coupling with $\alpha_P(0) = 1$ has recently been developed by the authors [12].

‡ This argument was first given by the authors of ref. [6]

⨥ Experimentally, from the near constancy of the total cross section at high energies, we know that $\alpha_P(0)$ is very close to 1.

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