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AN f^o-DOMINATED POMERON AND POMERON COUPLINGS*

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ABSTRACT

We assume that the Pomeron can couple directly to the f^o-meson through a t-dependent coupling. We take as given the fact that the triple-Pomeron coupling vanishes at zero Pomeron masses. Our major result is that any diagram that has a Pomeron connected to it vanishes when the mass of the Pomeron is zero.

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I. INTRODUCTION

The problem of the self-consistency of a factorizable Pomeron trajectory near J=1 was first studied by Finkelstein and Kajantie.[1] They found that unlimited exchange of the Pomeron trajectory lead to the conclusion that $\alpha_P(0) < 1$ if Pomeron couplings are non-zero at t=0. This result was also obtained by Chew and his collaborators, within the framework of multiperipheral models,[2] where if $\alpha_P(0) = 1$, the Pomeron decouples from all other particles and trajectories at t=0. Recently, there has been considerable interest in the triple-Pomeron vertex $\bar{g}_P(t)$. It is believed that if the Pomeron is a Regge pole with $\alpha_P(0) = 1$, then $g_P(0) = 0$. This result has been obtained from unitarity,[3] in dual resonance models,[4] from sum rules expressing conservation of energy and momentum in terms of inclusive cross sections,[5] the Gribov Reggeon calculus,[6] and multiperipheral models.[2] There is also considerable experimental evidence that suggest the triple-Pomeron vertex either vanishes identically or is very small.[7]

In this paper we construct a model of Pomeron couplings. The basis of our model is the assumption that the Pomeron can couple directly to the f^o-meson (2^+, 1250) through a t-dependent coupling $d_1(t)$. We take as given the vanishing of the triple-Pomeron vertex at t=0, i.e., $g_P(0) = 0$. Our major result is that any diagram that has a Pomeron connected to it vanishes when the mass of the Pomeron is zero. In Section II we give the details of the model and some of the consequences which follow. Section III is devoted to a discussion of some related matters.

II. THE MODEL

The model is defined by the following two assumptions: (a) The Pomeron can couple directly to the f^o-meson (2^+, 1250) by means of a t-dependent coupling $d_1(t)$; (b) the triple-Pomeron coupling vanishes for zero Pomeron masses. The assumption (a) is strongly suggested by duality sum rules,[8] while as stated in the Introduction (b) seems to be a general consequence of unitarity once we assume the Pomeron is a Regge pole at $\alpha_P(0) = 1$.

The general triple-, double-, and single-Pomeron vertices are given in Fig. 1. We require $g_2(t_1, t_2, \omega)$ and $g_3(t_1, t_2, t_3)$ to be completely symmetric in the Pomeron masses, i.e.,

$$g_2(t_1, t_2, \omega) = g_2(t_2, t_1, \omega) \quad , \tag{1}$$

$$\begin{aligned} g_3(t_1, t_2, t_3) &= g_3(t_2, t_1, t_3) = g_3(t_3, t_2, t_1) \\ &= g_3(t_3, t_1, t_2) = g_3(t_1, t_3, t_2) \\ &= g_3(t_2, t_3, t_1) \quad . \end{aligned} \tag{2}$$

In our model, the vertices for the various Pomeron couplings are defined by the diagrams in Fig. 2. In this "pole-approximation," the following results are obtained,

$$g_1(t) = g_f\, d(t) \quad , \tag{3}$$

$$2g_2(t_1, t_2) = g_1(t_1)\, d(t_2) + g_1(t_2)\, d(t_1) \quad , \tag{4}$$

$$3g_3(t_1, t_2, t_3) = g_2(t_1, t_3)\, d(t_2) + g_2(t_1, t_2)\, d(t_3) + g_2(t_2, t_3)\, d(t_1) \quad . \tag{5}$$

Here, g_f is the triple-f^o coupling, d(t) is

$$d(t) = \frac{d_1(t)}{\pi(m_f^2 - t)} \quad ,$$

and the ω dependence in g_2 has been suppressed. Using the fact that $g_3(0,0,0)=0$, we obtain from Eqs. (3) - (5),

$$g_2(0,0) = 0 \quad , \tag{6a}$$

$$g_1(0) = 0 \quad , \tag{6b}$$

$$d(0) = 0 \quad . \tag{6c}$$

The result, $d(0)=0$, means that any diagram that has a Pomeron joined to it <u>vanishes</u> when the mass of the Pomeron is <u>zero</u>. We now give, in more detail, some consequences of this result:

(1) The triple-Pomeron vertex, $g_p(t) = \Gamma_{PPP}(t,t,0)$, is identically zero. However, the general triple-Pomeron vertex, $\Gamma_{PPP}(t_1,t_2,t_3)$, where none of the legs is at zero mass, is not expected to vanish. If any of the legs is at zero mass the vertex vanishes.

(2) The Pomeron-Pomeron-Reggeon vertex, $\Gamma_{PPR}(t_1,t_2,t_3)$, vanishes if either or both Pomerons is at zero mass, i.e.,

$$\Gamma_{PPR}(0,t_2,t_3) = \Gamma_{PPR}(t_1,0,t_3) = \Gamma_{PPR}(0,0,t_3) = 0 \quad . \tag{7}$$

(3) The Reggeon-Reggeon-Pomeron vertex, $\Gamma_{RRP}(t_1,t_2,t_3)$, vanishes at zero mass of the Pomeron leg and arbitrary masses for the Reggeon legs.

(4) The Pomeron-Pomeron-particle, $\Gamma_{PPd}(t_1,t_2,\omega)$, and the Pomeron-Reggeon-particle, $\Gamma_{PRd}(t_1,t_2,\omega)$, vertices vanish if a Pomeron leg is at zero mass.

(5) The Pomeron decouples from all total cross sections, i.e., the Pomeron-particle-particle vertex, $\Gamma_{Pdd}(t)$, vanishes for $t=0$.

(6) The Mueller vertices, Fig. 3, vanish when any Pomeron leg is at zero mass.

III. DISCUSSION

It is interesting to note, that many of the results obtained in this paper, using a specific model, have been obtained by Jones et al.,[9] in an essentially model independent manner. They assume the validity of asymptotic Regge pole expansions, unitarity and exact sum rules to reach conclusions concerning the couplings of the Pomeron. They, as we do in this paper, assume the Pomeron is a Regge pole and do not consider possible Regge cuts in the neighborhood of J=1. If Regge cuts are present, then the strong results obtained in Section II would not necessarily hold. In fact, it has been suggested that (i) the Pomeron is different from other Regge poles in that it may not be considered separately from its cuts;[10] (ii) the Pomeron may not be a Regge pole, but a cut.[11]

Some information on the nature of the Pomeron singularity may be obtained by testing the factorizability of the diffraction dissociation amplitude. If the Pomeron is a Regge pole the residue should factor and thus different processes should be related to each other. The factorization has been checked in both two-body[12] and many-body[13] final states. The data is in reasonable agreement with factorization of the Pomeron residue; however cuts are not excluded. One may also check for long-range correlations in diffractive processes. Using Mueller's Regge analysis of inclusive processes,[14] one can show that long-range correlations correspond to failure of the Pomeron singularity to factorize.[15]

It can be shown that the N-particle inclusive cross sections and the two-body elastic cross sections can not both be dominated by the exchange of an isolated, factorizable Pomeron.[16] Also, within the context of the S-channel unitarity constraint of multiperipheral bootstrap models,[17] one obtains the result that we can have either a leading Regge pole with $\alpha_P(0) < 1$, or a cut with branch point at $\alpha_P(0) = 1$.

A reaction where the triple-Pomeron vertex might be easily measured is the inclusive reaction $\gamma + A \rightarrow \phi + X$. Near the boundary of phase-space,[18] we expect triple-Regge behavior.[7] Using the vector-meson dominance model, we may replace the photon by a phi-meson. In terms of Regge exchange, the phi-meson vertex couples only the Pomeron;[19] thus, we obtain,

$$\frac{d^2\sigma}{dt\, d\left(\frac{M^2}{s}\right)} \propto g^2_{\phi\gamma} \left(\frac{s}{M^2}\right)^{2\alpha_P(t)-1} \left[g_P(t) + \sum_i \epsilon_i g_i(t) \left(M^2\right)^{\alpha_i(0)-1}\right] . \tag{8}$$

Here, $g_{\phi\gamma}$ is the direct phi-photon coupling; $g_P(t)$ is the triple-Pomeron coupling; $g_i(t)$ is the Pomeron-Pomeron-Reggeon vertex; $\alpha_i(0)$ is the t=0 intercept of the lower lying Regge trajectories; and, ϵ_i is the ratio of Regge couplings, at t=0, between particle A and Regge trajectories $\alpha_P(0)$ and $\alpha_i(0)$, i.e.,

$$\epsilon_i = \frac{\Gamma_{AAP}(0)}{\Gamma_{AAR}(0)} \rightarrow \frac{\Gamma_{AAR}(0)}{\Gamma_{AAP}(0)} \quad .$$

Using Eq. (8), the triple-Pomeron vertex may be evaluated directly from experiment.

Finally, we note that Eqs. (3) - (5) may be written,

$$g_1(t) = g_f\, d(t) \quad , \tag{9}$$

$$g_2(t_1, t_2) = g_f\, d(t_1)\, d(t_2) \quad , \tag{10}$$

$$g_3(t_1, t_2, t_3) = g_f\, d(t_1)\, d(t_2)\, d(t_3) \quad . \tag{11}$$

The following results are easily obtained,

$$\frac{\partial^N g_2(0,t)}{\partial t^N} = 0 \quad , \tag{12}$$

and

$$\frac{\partial^{N+M} g_3(0, t_1, t_2)}{\partial t_1^N \, \partial t_2^M} = 0 \quad . \tag{13}$$

Equation (13) is a generalization of results obtained by Muzinich, Paige, Trueman and Wang,[20] who show that the Gribov-Midgal lower bound on the magnitude of the two-Pomeron cut is not valid unless both the triple-Pomeron coupling and its derivative vanish at zero Pomeron masses.[21]

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18. We define the following variables: $S = (P_\gamma + P_A)^2$, $t = (P_\gamma - P_\phi)^2$, and M = (missing-mass). Near the boundary of phase-space, we have t-fixed, $s \to \infty$, $M^2 \to \infty$, with $s/M^2 \to \infty$.

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FIGURE CAPTIONS

1. The general single-, double-, and triple-Pomeron vertices; ω is a Toller-like angle.

2. Definition of Pomeron vertices in an f^0 pole-dominated model.

3. Mueller vertices.

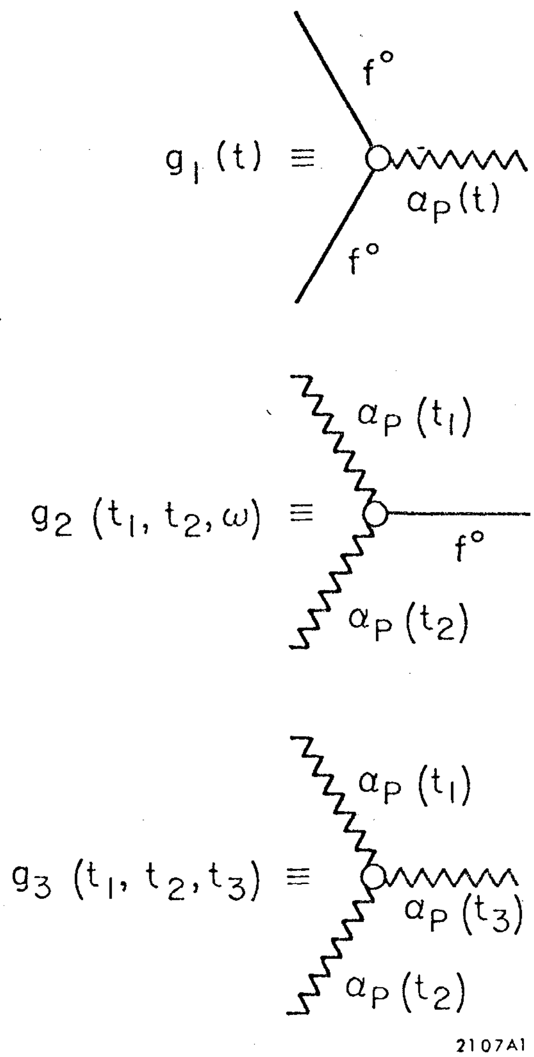
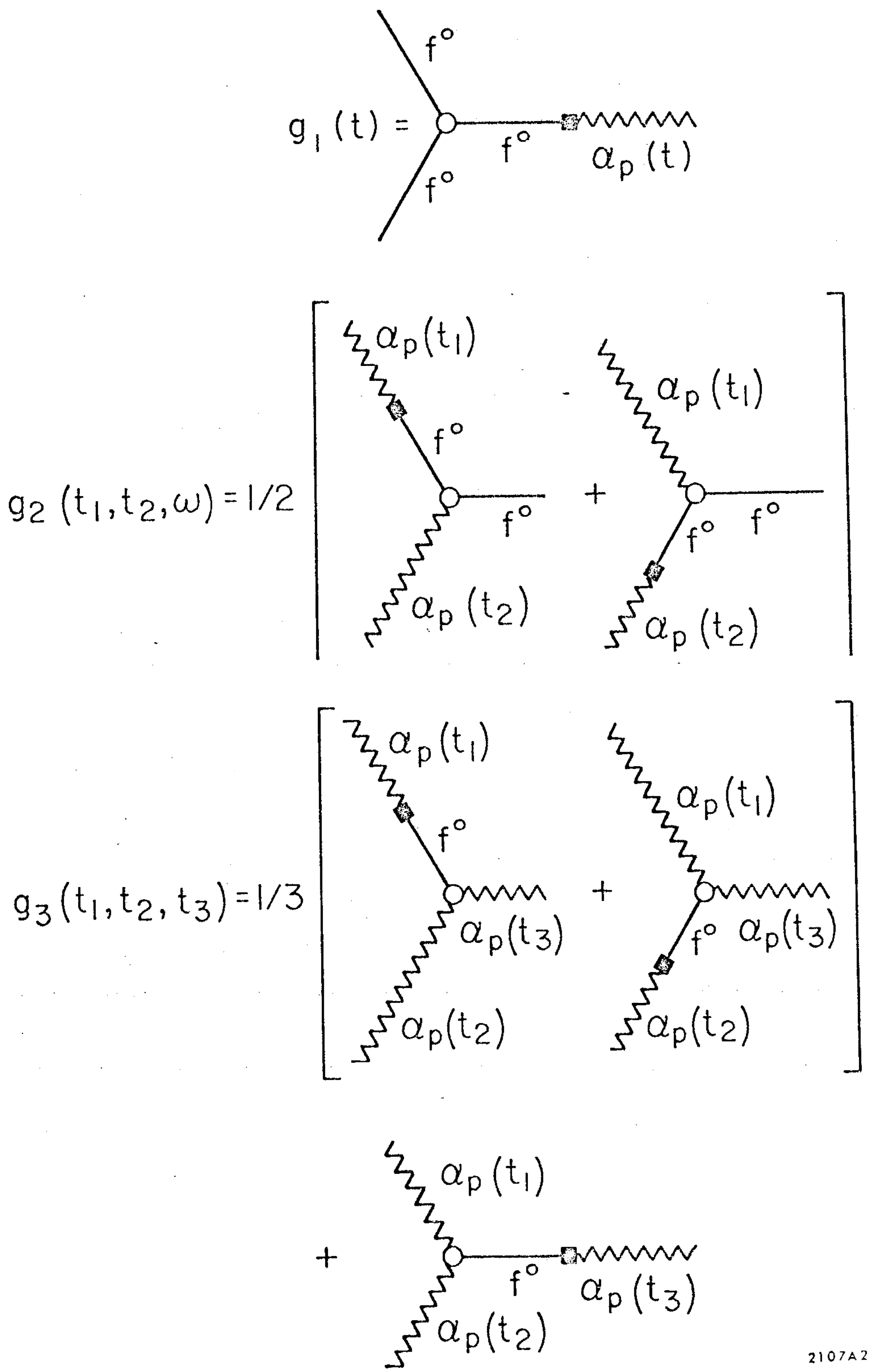

g1 (t) ≡
f°
f°
αP(t)
g2 (t1, t2, ω) ≡
αP (t1)
f°
αP (t2)
g3 (t1, t2, t3) ≡
αP (t1)
αP (t3)
αP (t2)
2107A1

Fig. 1



g₁ (t) =
f°
f°
f°
αp (t)
g2 (t1, t2, ω) = 1/2
αp (t1)
f°
f°
αp (t2)
+
αp (t1)
f°
f°
αp (t2)
g3 (t1, t2, t3) = 1/3
αp (t1)
f°
αp (t3)
αp (t2)
+
αp (t1)
f°
αp (t3)
αp (t2)
+
αp (t1)
f°
αp (t3)
αp (t2)
2107A2

Fig. 2

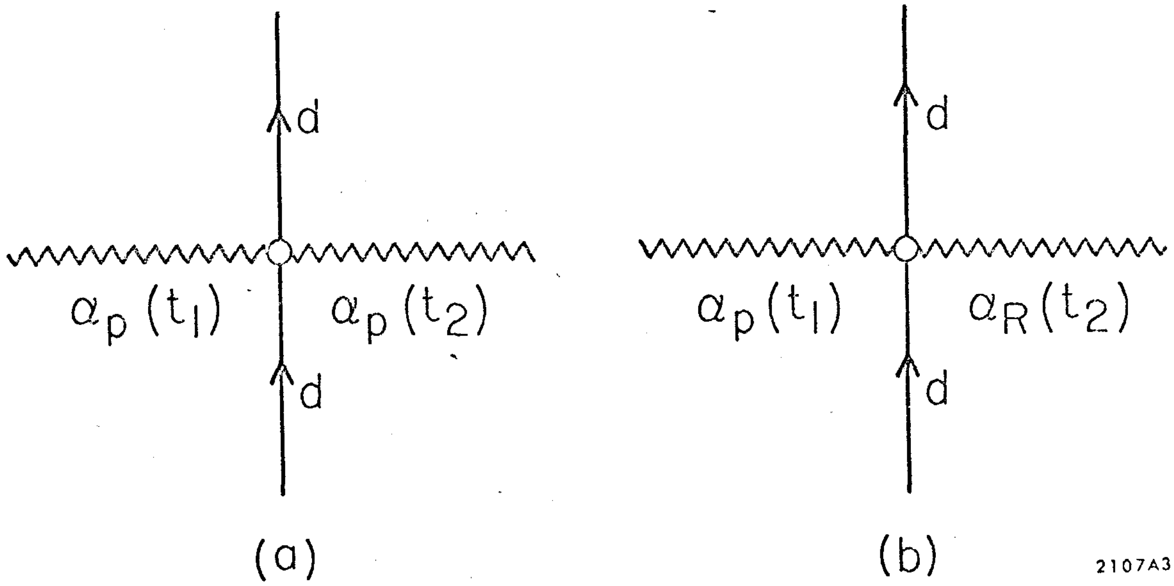


Fig. 3