Parton model of pomeron with $\alpha(0) > 1$

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It is shown that in the parton model (PM) the values of the three-pomeron constant λ and of the pomeron intercept $\Delta = \alpha(0)-1$ are connected by the relation $\lambda = \Delta$. For this reason a critical behavior turned out to be impossible in reggeon field theory. Arguments based on the PM make it possible to distinguish between the regions where the approaches of Cardi (Nucl. Phys. **B75**, 413, 1974 and elsewhere) and Amati and co-workers (Nucl. Phys. **B101**, 397, 1975 and elsewhere) are applicable. In the latter approach the total cross sections decrease asymptotically.

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1. Much progress was made recently in the reggeon field theory (RFT). The considered theoretical schemes differ in the values of two principal parameters: the pomeron intercept $\alpha_P(0) = 1 + \Delta$, and the three-pomeron coupling constant λ. The

following approaches are known: the weak-coupling variant[8] $\Delta=\lambda=0$; the critical regime,[9] which is realized at values $\Delta=\Delta_c\approx\lambda^2\ln\lambda^2$ and schemes with $\Delta>\Delta_c$. In the latter case two approaches were developed, which differ substantially in their results. In one of them[6,7] account is taken of only three-pomeron interaction, while in the other[1-5] all the multipomeron coupling constants are added.

In the present article we interpret the RFT diagrams from the point of view of the parton wave function of a hadron, and obtain a number of constraints on the aforementioned theoretical schemes.

2. We shall show that the parton model (PM)[19,11] leads to a rigorous relation in schemes with three-pomeron interaction[1)]:

$$\Delta = \lambda . \tag{1}$$

The parton wave function of a fast hadron is determined by a sum of contributions of the parton "combs" that make up various configurations, examples of which are shown in Fig. 1. The crosses mark those slow partons that have interacted with the target. The parton combs that "have spread out" after the interaction, i.e., produced real hadrons, are shown by thick lines. The thin lines mark those combs which did not take part in the interaction. They play the role of vacuum fluctuations. To obtain the contribution of the bare pomeron to the scattering amplitude in the parton wave function, it is necessary to separate only the diagrams that do not contain a 2→1 comb coalescence (see Fig. 1). In addition we must confine ourselves to the impulse approxi-

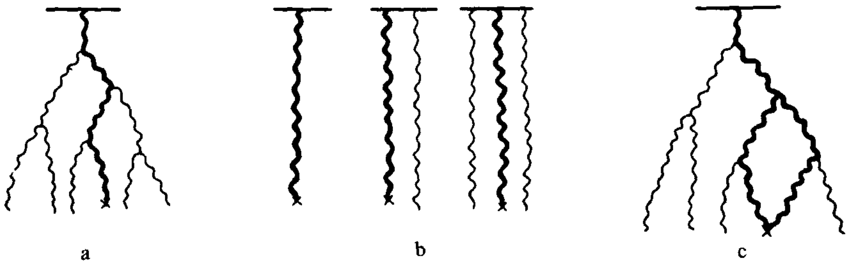

FIG. 1.

mation in the amplitude of the interaction of the target with the system of slow partons. Since the contribution of the bare pomeron to the total cross section increases like $\exp(\xi\Delta)$, where $\xi=\ln(s/s_0)$, it follows that the average number of slow partons in the hadron should increase with energy[11]

$$< n(\xi) >_{wee} = e^{\xi\Delta} . \tag{2}$$

It follows from Lorentz invariance that the relative contribution of diagrams of the non-enhanced type, shown in Fig. 1(b) cannot increase with ξ. These diagrams are therefore unable to ensure an increase in the number of slow partons (2). Only diagrams of the tree type are left [Fig. 1(a)]. Since the probability of the division of one comb into two is by definition equal to λ, we can write the equation

$$\partial \langle n \rangle_{wee} / \partial \xi = \lambda \langle n \rangle_{wee} . \quad (3)$$

From a comparison of (2) and (3) we obtain the relation (1).

3. The effective values of Δ and λ are obtained from the experimental data. The value of Δ is determined by the data on the growth of the total cross sections of the hadron interaction. We neglect here the contribution of the enhanced diagrams, i.e., it is assumed that $\lambda \ll 1$. The obtained[2-4] value is $\Delta \cong 0.07$. From this and from (1) it follows that λ is indeed small, so that this method of determining Δ is self-consistent.

The value of the three-pomeron effective constant is determined by the data on the inclusive cross section in the three-reggeon region.[12] However, the contribution of the cuts in such processes can be quite large[13] and the obtained value of λ_{eff} can differ strongly from λ. By definition, $\lambda_{\text{eff}} = [8\pi/\alpha'_P(\sigma_{\text{tot}}^{pp})^3]^{1/2}\ G_{PPP}$, where G_{PPP} is defined in[12], and $G_{PPP}(0) = 3.2$ mb/GeV^2. Substituting here $\alpha'_P = 0.3$ (GeV/c)$^{-2}$ and $\sigma_{\text{tot}}^{pp} = 40$ mb, we obtain $\lambda_{\text{eff}} = 0.07$. The striking accuracy with which the experimental data satisfy (1) indicates that the corrections for the rescattering cancel out in the three-reggeon region.

The reasons for this are not yet clear.

In the definition of G_{PPP} in[12] it was assumed that $\alpha(0) = 1$. An attempt to take into account the fact that $\alpha > 1$ in the three-reggeon region[14] changes the value of $G_{PPP}(0)$ by apparently not more than a factor of 1.5.

4. In view of the smallness of Δ, the relation (1) cannot be satisfied in the case $\Delta = \Delta_c \approx \lambda^2 \ln\lambda^2$, so that no critical regime is possible in the RFT.

Amati *et al.*[6] obtained the asymptotic form of the scattering amplitude in the approximation $\Delta \gg \lambda$. If relation (1) is substituted in their result, then it becomes obvious that the total cross section should decrease asymptotically with energy in power-law form[2]. In the parton model, nonetheless, the cross section should increase like ξ^2 and one can see no reason for the decrease of the cross section. The disparity with the RFT is apparently due to the use of the approximate lattice method in[6].

5. The use of the PM makes it possible to resolve also the following paradox:

In the RFT, variant which takes into account only the three-pomeron interaction, the average rapidity interval negotiated by the pomeron without interaction is $1/\Delta$.[7] Therefore the addition of other multipomeron constants does not influence the results if these constants are small: $g_{mn} \ll \lambda$ ($g_{21} = 2\lambda$ in the normalization of[11]). Under this condition the considered RFT variant is self consistent.

On the other hand, the scheme proposed by Cardi leads under the same conditions to entirely different results.[2-5]

It was shown in[2] that in the Cardy scheme we have the effective renormalization $\Delta \to \Delta_0 = \Delta - g_{11}$. Thus, the results of this scheme[1-5] are valid if $\Delta_0 > 0$. In the RFT it is impossible to determine the sign of Δ_0, but the PM makes this possible. Relation (1) is replaced in this case by

$$\Delta = \sum_{n=2}^{\infty} \frac{n-1}{n!}\, g_{1n} . \quad (4)$$

If g_{mn} is taken in the eikonal form $g_{mn} = g_{00} g^{m+n}$, then we get from (4)

$$\Delta_0 = g_{00} g(g-1)(e^g - 1) , \quad (5)$$

Thus, the results of the Cardi scheme are valid only at $g > 0$, while the Amati variant is meaningful only at $g \ll 1$. This resolves the paradox. We note that estimates[2] in the one-pion model yield $g \approx 1$.

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1) The normalization of λ corresponds here to the three-pomeron term in the RFT Lagrangian, of the form $i\psi^{+}\psi(\psi+\psi^{+})$.

2) We are grateful to M.G. Ryskin for clarifying some questions connected with[6].

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