Magnitude of three-pomeron vertex

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It is shown that when the first two orders of perturbation theory are taken into account it is impossible to obtain a small bare three-pomeron vertex r that agrees with the experimental data. Inclusion of the third order leads probably to $r/r_{\text{eff}} \approx 4$.

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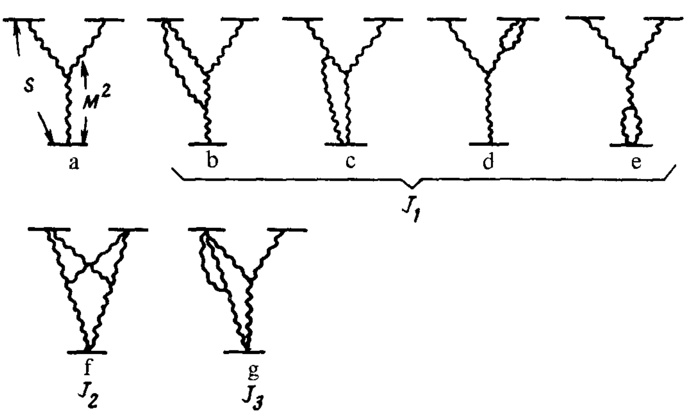
For inclusive cross sections in the region of the three-reggeon limit, the relative magnitude of the non-enhanced branch cuts is four times larger than the contributions of the non-enhanced branch cuts to the total cross sections (there are no identical reggeons and the complex-conjugate diagram is taken into account). Therefore the contribution of the three-pomeron diagram is cancelled out. Because of this, an increase takes place also in the negative contribution of the semi-enhanced branch cuts. As a result, the bare three-pomeron vertex r, which was usually assumed equal to the effective $r_{\text{eff}} \approx (1/40)g$, [1] is altered ($g$ is the vertex of the interaction of the pomeron with the particle, $g^2 \approx 50$ mb). To obtain r, it is necessary to take into account the contributions of the higher orders of perturbation theory.

In this paper we take into account the contributions of the first two orders in r (Fig. 1) and the non-enhanced absorption corrections to the diagrams of Fig. 1.

At $q_\perp^2 = 0$ the contributions of these diagrams to $E(d^3\sigma/dq^3)$ yield

$$\frac{g^3 r}{16\pi^2}\{1 + J_1 + J_2 + J_3 + \dots\} = \frac{g^3 r_{\text{eff}}}{16\pi^2} \quad . \tag{1}$$



The diagrams were calculated at $\xi = \ln(s/1\ \mathrm{GeV}^2) = 8$ and $\eta = \ln(M^2/1\ \mathrm{GeV}^2) = 5$ (the corresponding value is $X = 0.95$). The pomeron-particle interaction radii were chosen to be $R^2 = 2$, 4, and 6 GeV^{-2}, and the slope of the trajectory was taken to be $\alpha' = 0.3\ \mathrm{GeV}^{-2}$. The three-pomeron vertex was chosen pointlike. The absorption corrections up to third order inclusive were taken into account at $R^2 = 2$, and up to second order at $R^2 = 4$ and 6. As a result we obtained from (1) for r/g the equation

$$I_1(R^2)\left(\frac{r}{g}\right) - I_2(R^2)\left(\frac{r}{g}\right)^2 \approx \frac{1}{40} , \tag{2}$$

where

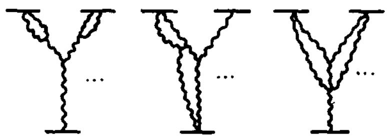
$I_1(2) \approx 0.4$; $I_1(4) \approx 0.6$; $I_1(6) \approx 0.7$;

$I_2(2) \approx 2.3$ $I_2(4) \approx 4.4$ $I_2(6) \approx 4.0$.

At $R^2 = 2$ and 4 Eq. (2) has no real solutions for r/g; at $R^2 = 6$ there appears the solution $(r/g) \approx 0.09 \pm 0.04$.

But this value of the radius cannot be reconciled with the slope of the diffraction peak in elastic scattering[2] and in the inclusive cross sections,[3] with yield $R^2 = 2\ \mathrm{GeV}^{-2}$.

Rough estimates show that at $R^2 = 2$ the coefficient of $(r/g)^3$ in (1) is positive and is of the order of 10—50. If the coefficient of $(r/g)^4$ is of the same order, then this allows us to obtain the solution[1)] $(r/g) \sim 1/10$, which results from the contributions of the diagrams of second and third (Fig. 2a) orders. If such a solution is realized, then the effective slope α'_{eff} for the inclusive cross section decreases. Experiment yields $\alpha'_{\mathrm{eff}} \approx 0.15$ to 0.2.[4]



It is possible that the four-pomeron interaction (Fig. 2b and 2c) must be taken into account in the solution. To the order of $\lambda r/g^2$, the diagrams give a positive contribution that cancels part of the contribution to the $(r/g)^2$ order.

Owing to the fact that (r/g) has increased, the contributions of the branch cuts leads to a faster growth of σ_{tot} with energy, and this possibly agrees with experiment. The change of the total cross section[5]

$$\Delta\sigma = g^2\left(1 - \left(\frac{r}{g}\right)\frac{\gamma_p}{4\alpha'}\ln\left(1 + \frac{\alpha'\xi}{R^2}\right)\right)^2\left(\frac{r}{g}\right)^2 \gamma_p \frac{\Delta\xi}{4\alpha'} , \tag{3}$$

where $\gamma_p = g^2/8\pi$, amounts to 3.7 mb in the energy interval from $E_{lab} = 30$ GeV to $E_{lab} = 1.5 \times 10^3$ GeV ($\Delta\xi \approx 3.9$).

An approximate upper bound on r/g can be obtained from the fact that the experimentally observed distribution with respect to rapidity in the beam does not depend on $q_\perp^2$.[4] This means that processes with formation of several beams (Fig. 1f) are small, i.e., $J_2 < 1$:

$$J_2 = \frac{r}{g}\gamma_p^2 3\eta C^3 \{8[\alpha'(\xi - \eta + \ln 2) + R^2][\alpha'(\xi + \eta - \ln 2) + 3R^2]\}^{-1}, \tag{4}$$

where $C^2 = 1.3$. From this equation we get $(r/g) < 0.14$.

We call attention in conclusion to the values of the parameters that are typical of the reggeon perturbation theory:

$$\rho_1 = (r/g)^2(\gamma_p/4\alpha')\xi \text{ and } \rho_2 = (r/g)(\gamma_p/4\alpha')\ln(1 + \alpha'\xi/R^2).$$

At $(r/g) \approx 1/10$ and $\xi \approx 8$ we have $\rho_1 \approx \rho_2 \approx 1/3$. If (r/g) is somewhat larger, e.g., $(r/g) = 1.7$, then $\rho_1 \approx 2/3$ and then we are in the region of the transition to the asymptotic regime.[5]

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1)We note that allowance for only absorption corrections to the diagram of Fig. 1a (i.e., if contributions of order r^2 are discarded) leads to $(r/g) \approx 1/16$.

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