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MULTIPLICITY IN DIFFRACTION DISSOCIATION PROCESSES AT HIGH ENERGIES

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We study the contribution of the three-pomeron mechanism to the average multiplicity of hadrons produced at high energies. We show that this mechanism leads to a doubly-logarithmic contribution $\langle n\rangle_D \simeq 10^{-2} a \ln^2 s/s_0$ in addition to the contribution $\langle n\rangle \simeq a \ln s$ of the multiperipheral mechanism. The connection with other fragmentation models is discussed.

The pp → pK inclusive experiments at ISR [1] have revealed the presence of forward-scattering peaks corresponding to diffraction dissociation (DD) of one of the colliding particles on a beam with large invariant mass M.

In the three-reggeon (TR) scheme these peaks are described by the contribution of the three-pomeron (TP) vertex, and neither a vanishing nor nonvanishing TP vertex at zero momentum transfer is as yet in disagreement with experiment [2]. It is therefore of interest to examine the consequences of these alternatives for the average multiplicity of the particles (pions) produced in accomaniment with the observed proton p in the considered kinematic region.

If we interpret various fragmentation models in TR language, then the problem reduces to determining the dependence of the cross section $\sigma_{Pp}(t, M^2)$ for the scattering of a pomeron P by a proton, with allowance for the relative suppression of productions of beams with large M. Thus, the description of the inelastic diffraction peak by means of the non-scaling term PPR (R - secondary trajectory with $\alpha_R(0) = 0.5$) leads to a DD contribution $\sigma_D \sim$ const to the total cross section and to an average multiplicity $\langle n\rangle_D \sim \ln s$ [3]. Moreover in [4], where a zero TP vertex PPP was assumed and only trajectories with $\alpha_R(0) < 0.5$ were believed to contribute to PPR, it was concluded that the double DD cross section decreases, $\sigma_{DD} \sim \ln^{-1} s$, and the multiplicity $\langle n\rangle_{DD}$ is constant. In both cited papers it was assumed for saturation of $\langle n\rangle$ that the multiplicity in the beams is maximal, $\langle n(M^2)\rangle \sim M$. This question was considered in [5] for a TP vertex that does not vanish at t = 0, under the self-consistent multiperipheral assumption $\langle n(M^2)\rangle \sim \ln M$, and it was concluded that $\langle n\rangle_D$ increases logarithmically, like ln s. There however, the average multiplicity $\langle n\rangle_D'$ in DD processes was not quite correctly identified with the DD contribution $\langle n\rangle_D$ to the total average multiplicity.

It is shown in the present paper that in the pre-asymptotic region (the ISR energy region) there is besides the growth $\sigma_D \sim \ln s$ also a doubly-logarithmic growth $\langle n\rangle_D \sim \ln s$. The TP contribution to the pp → pX spectrum is $(\alpha_P(0) = 1)$

$$\frac{d\sigma}{dt\,dM^2} = \frac{G(t)}{M^2}\left(\frac{s}{M^2}\right)^{2\alpha_P' t}, \tag{1}$$

where for the effective TP vertex G(t) is chosen in the form $G(t) = -\tilde{G}t\exp(\tilde{R}^2 t)$ and $G(t) = G(0)\exp(R^2 t)$ for the case when it vanishes and does not vanishes, respectively, at zero t. It is assumed that the Pp → X process is similar to the usual hadron process, i.e., that its average multiplicity, normalized to σ_{Pp}, takes at large M^2 the form

$$\langle n(t, M^2)\rangle \simeq a \ln M^2, \tag{2}$$

		Pre-asymptotic	Asymptotic
$\langle n \rangle_D'$		$\frac{a}{2} \ln \frac{s(1-x_o)}{M_o^2}$	$a \ln s$
$\langle n \rangle_D$	$PPP(0) \neq 0$	$\frac{G(0)\,a}{\left(R^2+2\alpha_p' \ln \frac{1}{1-x_o}\right)\sigma_{tot}} \ln^2 \frac{s(1-x_o)}{M_o^2}$	$\frac{G(0)\,a}{\alpha_p' \sigma_{tot}} (\ln s) \ln\ln s$
	$PPP(0) = 0$	$\frac{\tilde{G} a}{\tilde{R}^2\left(\tilde{R}^2+2\alpha_p' \ln \frac{1}{1-x_o}\right)\sigma_{tot}} \ln^2 \frac{s(1-x_o)}{M_o^2}$	$\frac{\tilde{G} a}{\alpha_p'\left(\tilde{R}^2+2\alpha_p' \ln \frac{1}{1-x_o}\right)\sigma_{tot}} \ln s$

where a is of the same order as in ordinary hadronic processes [6]. In this case we get for the integrated multiplicities

$$\langle n \rangle_D = \langle n \rangle_D' \frac{2\sigma_D}{\sigma_{tot}} = \frac{2a}{\sigma_{tot}} \int \ln M^2 \left(\frac{d\sigma}{dt\, dM^2}\right) dt\, dM^2 , \tag{3}$$

where

$$\sigma_D = \int \left(\frac{d\sigma}{dt\, dM^2}\right) dt\, dM^2 \tag{4}$$

was calculated in [2]. The results for the pre-asymptotic ($\delta = (2\alpha_p'/R^2)\ln s \ll 1$) region and the asymptotic region ($\delta \gg 1$) are listed in the table. The integration is over the region $M_0^2 \leq M^2 \leq M_{max}^2 = s(1 - x_0)$. To separate only the TP contribution, M_0 should be large enough ($M_0^2 > 4 - 5$ GeV) and M_{max} small enough ($x_0 \gtrsim 0.85 - 0.9$) [2]. The numerical values of $\langle n \rangle_D$ for the pre-asymptotic region, with allowance for the parameters obtained in [2], coincide and are equal to $\langle n \rangle_D \simeq 10^{-2} a \ln^2 s/s_0$, $s_0 \simeq 30 - 50$ GeV .

Thus, the energy behavior of the multiplicities $\langle n \rangle_D$ and $\langle n \rangle_D'$ at present-day energies do not make it possible to distinguish between two possible bahviors of the TP vertex at t = 0. However, the doubly logarithmic contribution coming from the TP vertex can explain in part the fast growth of $\langle n(s) \rangle$ observed at large s [6]. As noted in [2], the contribution of the TP mechanism, $2\sigma_D$, can account also for the observed increment of the total cross section, $\sigma_{tot} \simeq 4$ mb. The numerical value of the TP constant $g_p(0)$ is small enough ($\eta = g_p^2(0)/32\pi\alpha_p' \sim 10^{-3}$) [2], so that the double DD and the leading two-pomeron exchange can be regarded at contemporary energies as higher corrections in terms of the parameter $\eta \ln s$ [7].

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