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THE DIFFRACTIVE DISSOCIATION OF HADRONS INTO THE HIGH MASS STATES

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1. Let us consider the inclusive reaction $a+b\to X+b$ in the triple-regge region: $M_X^2 \gg s_0$, $\frac{s}{M_X^2} \gg 1$. Here $s_0 = 1\,GeV^2$, M_X is the X effective mass. It is known (see, for instance, ref.[1]) that if $x\to 1$ ($x = 1 - \frac{M_X^2}{s}$) then the triple-pomeron contribution to the inclusive cross section will dominate

$$\left(s\frac{d^2\sigma}{dM_X^2\, dq_\perp^2}\right)_{PPP} = G_{PPP}(q_\perp^2)\left(\frac{s}{M_X^2}\right)^{2\alpha_P(q_\perp^2)-\alpha_P(0)}\left(\frac{s}{s_0}\right)^{\alpha_P(0)-1} . \quad (1)$$

It is seen that the pomeron intercept $\alpha_P(0)>1$ leads to the violation of the Feynman scaling, as the cross section increases with energy. Here we shall prove that this increase will be changed to a fast drop.

2. In the constituent quark model the triple-pomeron term corresponds to a case when only one constituent quark in a hadron dissociates into a high mass, while the other quarks are the spectators or produce a small mass state*.

Diffraction of a constituent quark is considered here in the eigenstate method[4-7]. The diffractive amplitude of α into β has a from $f_{\alpha\beta} = \sum_k c_k^\alpha c_k^\beta f_k$, where f_k is the scattering amplitude in a state $|\alpha, k\rangle$, which has definite number $k = 0,1,2\ldots$ of wee partons. The coefficient $c_k^\alpha = \langle \alpha, k|\alpha\rangle$.

In a case of constituent quark one can apply the two-component approximation[4,5], where $f_k = f$ if $k \geq 1$, and $f_0 = 0$. This assumption leads to $f_{\alpha\beta} = f(\delta_{\alpha\beta} - c_0^\alpha c_0^\beta)$. The cross section of quark diffraction dissociation, which is summed over all the final states with $M_\beta^2 < M_X^2$, is equal to:

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* In the quark model the PPR term is related with valon scattering - the process discussed in papers[2,3].

$$\frac{d\sigma^q_{diff}}{dq_\perp^2} = \frac{d\sigma_{el}}{dq_\perp^2} |c^q_0|^2 \frac{1}{P_q^2(s)} \left(\sum_{M^2_\beta < M^2_X} |c^\beta_0|^2 - |c^q_0|^2 \right) \qquad (2)$$

after elastic cross section subtraction.

One can see that the sum $\sum_{M^2_\beta < M^2_X} |c^\beta_0|^2$ equals to the contribution into the total passive state norm $\langle q,0|q,0\rangle$, which is connected with passive parton fluctuations, containing no parton with rapidity smaller than $y = \ln(s/M_X^2)$. On the other hand, the sum of such state norms is equal to the relative probability of transition from active state to a passive one when the quark rapidity is increased under Lorentz transformation from zero to $\ln(M_X^2/s_0)$ [8]. Thus $\sum_{M^2_\beta < M^2_X} |c^\beta_0|^2 = |c^q_0(M_X^2)|^2 / |c^q_0(s)|^2$.

Substituting this result into expression (2), one obtains

$$s\frac{d^2\sigma_{diff}}{dM_X^2 dq_\perp^2} = -\frac{s}{M_X^2} \frac{d\sigma_{el}}{dq_\perp^2} \frac{1}{P_q^2(s)} \frac{d[P_q(M_X^2)]}{d[\ln(M_X^2/s_0)]}. \qquad (3)$$

Here $P_q = 1 - |c^q_0|^2$ is the weight of the quark active state.

3. Expression (3) and diffraction dissociation data give a possibility to determine with high accuracy the energy dependence of P_q. For example, if the quark energy is 100 GeV, $P_q = 0.57$ [9], $\sigma^{qN}_{tot} = 17$ mb [9], $G^{qN}_{PPP} \simeq (\sigma^{qN}_{tot}/\sigma^{NN}_{tot}) G^{NN}_{PPP}$, where [1] $G^{NN}_{PPP} = 3.2$ mb/GeV^2. After comparing (1) and (3) at $q_\perp^2 = 0$ one obtaines $d[\ln P_q]/d[\ln(s/s_0)] \approx -0.06$ for $s = 200$ GeV^2. This value is in good agreement with the results of analysis [10] of data on $K_L - K_S$ regeneration on nuclei.

4. The parton cascade model [11] gives the following expression $P_q(s) = P(\infty)/\{1 - [1 - P(\infty)](s/s_0)^{1-\alpha_P(0)}\}$. Taking $\alpha_P - 1 = 0.07$ [12] and $P_q = 0.57$, one finds $d[\ln P_q(s)]/d[\ln(s/s_0)] \approx -0.067$ which agrees very well with the value determined above.

This consideration can be reversed: if $(\alpha_P - 1)\ln(s/s_0) \ll 1$ the substitution of $P(s)$ from ref. [11] into the relation (3) leads to the approximate Feynman scaling. In this way one can calculate the effective triple-pomeron constant which is in good agreement with the known experimental value.

5. At high energies $(\alpha_P - 1)\ln(s/s_0) \gg 1$ the value of $d[P_q(s)]/d[\ln(s/s_0)]$ in (3) decreases [8] as a power of energy [11] $(s/s_0)^{1-\alpha_P}$. At the same time the value of cross section $d\sigma^{el}/dq_\perp^2$ cannot rise faster than a power of $\ln(s/s_0)$. Consequently the Feynman scaling should be strongly violated at

very high energies. Such phenomenon has been found indeed in the experiments with cosmic rays /18/. It should be seen also at the energies of future large accelerators.

6. The simultaneous energy dependent decrease of $P_q(s)$ and increase of σ_{tot}^{qN} lead to a specific behaviour of hadron-nucleus cross sections with energy: the cross section should increase for light nuclei and decrease for large nuclei. At the quark energy of 100 GeV, for instance, the total hadron-nucleus cross sections decrease with energy for the nuclei with the atomic number $A \gtrsim 30$. For the nuclei ^{207}Pb and ^{238}U such a decrease is visible: $d[\ln \sigma_{tot}^{qN}]/d[\ln(s/s_0)] \approx -0.03$ in accordance with the experimental data /19/.

7. The ratio of the real-to-imaginary parts of the elastic quark-nucleus scattering amplitude has the form /15/

$$\frac{\mathrm{Re}F^{qA}}{\mathrm{Im}F^{qA}} = -\frac{4\pi}{\sigma_{tot}^{qA}} \int d^2b \int dM^2 \frac{d^2\sigma_{diff}^{qN}}{dq_\perp^2\, dM^2}\Big|_{q_\perp^2=0} \times \tag{4}$$

$$\times[1 - P_q + P_q e^{-\frac{\sigma_{tot}^{qN} T(b)}{2P_q}}] \iint_{-\infty}^{\infty} d\ell_1\, d\ell_2\, \rho(b,\ell_1)\rho(b,\ell_2)\sin(\Delta q_2 |\ell_2 - \ell_1|)\,.$$

All notations here are from paper /15/. It is seen from (4) that in case of Feynman scaling the ratio (4) does not depend on energy. Substitution of (3) into (4) gives an approximately constant ratio (4) in a wide energy range. But at energies $(\alpha_P - 1)\ln(s/s_0) \gg 1$, ReF_{qA}ll tend to zero.

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