PARTON JET FRAGMENTATION AT SMALL $x$

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It is known /1,2/ that transverse momentum ordering does not hold for the fragmentation at small $x$ and has to be replaced by angular ordering. We apply the method of separation of the softest particle to this problem /3/. It allows to avoid the analysis of higher order graphs and provides a simple way for deriving equations. The method has been developed in application to quark scattering with quantum number exchange /4/.

We consider the amplitude and add a further loop (with momentum $k$) in all possible ways. Then we look for an approximation and a kinematical region $S_k$, such that the sum over the contributions with the additional loop can be expressed by a loop integral involving the original amplitude (separation of the loop from the amplitude). In double-logarithmic approximation the separation is always possible. In the case of the fragmentation at small $x$ $S_k$ is determined by the angular ordering condition.

Consider the Compton amplitude with an additional gluon $f_{\mu}(\rho, q, k)$. The gluon $k_{\mu}$ can be radiated from the external quark legs $\rho$ or from the inner part of the block.

$$f_{\mu}(\rho, q, k) = \frac{\rho_{\mu}}{\rho_{k}} f(\rho, q) + f_{\mu}(\rho, q, k) \quad (1)$$

$f(\rho, q)$ is the forward Compton amplitude. In the first contribution the gluon is separated. $f_{\mu}(\rho, q, k)$ obeys the Ward identity

$$k_{\mu} f_{\mu}(\rho, q, k) = f(p, k, q) - f(p, q) \quad (2)$$

In the Compton amplitude with an additional loop the double log approximation requires one pole factor $(p_k)^{-1}$, therefore

$$\overline{f}(\rho, q, k) = \frac{2 \rho_{\mu}}{(\rho_{k})} f_{\mu}(\rho, q, k) \quad (3)$$

Thus we have partial separation of the gluon loop. If now the direction of $k_{\mu}$ is much closer to $\rho_{\mu}$ than the directions of momenta in the block, we can replace $\rho_{\mu} \simeq \frac{2 \rho_{\mu}}{p_{\mu}} (k_{\mu} = q_{\mu} + p_{\mu}, q_{\mu} = q - \rho_{\mu})$ and apply eq. (2) to achieve full separation.

$$\overline{F}(\rho, q, k) \bigg|_{S_k} = \frac{2}{(p_{\mu})^2} \left( f(p, k, q) - f(p, q) \right) (4)$$

From this we obtain immediately an equation for the amplitude $f$ and specifying to the fragmentation function we recover the known results.

References: