Inclusive Electroproduction of Two Hadrons.

B. K. PAL

Physics Department, Imperial College - London

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The Mueller (1,2) method of combining Regge theory with unitarity (3) has been used to calculate the production of two hadrons in inclusive hadronic reactions (4). It is believed that the virtual photon behaves like a hadron in many respects if the mass of the virtual photon remains fixed. It is possible, therefore, to study the production of two hadrons in e.p. reactions in the same way as in hadronic reactions (3) if one uses the $Q^2$-dependent Regge residues outside Mueller's analysis by assuming factorization (5) that will fix this $Q^2$-dependence in the proton fragmentation region and in the central region (6,7). One has to appeal to the generalized scaling laws of the parton model (6) if the $Q^2$-dependence is to be determined in the current fragmentation region.

We find that the Lorentz-invariant cross-section $\frac{d^2\sigma}{d^3p_1d^3p_2}$ is independent of $v$ or $s$ for only large $s$ if we consider only the pomeron trajectory both in the Regge and scaling regions. The correction for $s$ not too large will come from nonpomeron trajectories. We also observe that there is no correlation between the fragmentation product of the current and that of the target.

\[\text{Fig. 1.}\]

The kinematics for inclusive electroproduction are depicted in Fig. 1a). All the states are normalized as $\langle \vec{p} \mid \vec{p}' \rangle = (2\pi)^3 2E^0 (\vec{p} - \vec{p}')$.

We introduce the following variables:

$$\begin{align*}
\nu &= p \cdot q / m, \quad \nu_1 = p_1 \cdot q / m_1, \quad \nu_2 = p_2 \cdot q / m_2, \\
k_1 &= p \cdot p_1 / m, \quad k_2 = p \cdot p_2 / m, \quad \omega = 2p \cdot q / Q^2, \\
o_1 &= 2p_1 \cdot q / Q^2, \quad o_2 &= 2p_2 \cdot q / Q^2,
\end{align*}$$

where $m$, $m_1$ and $m_2$ are the masses of the proton, produced hadron 1 and hadron 2, respectively, and, as usual, $Q^2 = -q^2$.

The process $\gamma_p + p \to p_1 + p_2 + X$ can be studied in many different regions. The three different regions we consider are depicted in Fig. 1b), 1c) and 1d), respectively. The extension of the original Mueller analysis from hadronic reactions to inclusive electroproduction gives the following Lorentz-invariant expressions (3) for

$$\begin{align*}
\frac{2(2p \cdot q + q^2)}{4\pi \nu} p_1^0 p_2^0 \frac{d\sigma}{d^3 p_1 d^3 p_2},
\end{align*}$$

in the three different regions. The central and nucleon fragmentation region (Fig. 1b)) is the one where the virtual photon hits the proton with fragmentation of the particle $p_2$ in the vertex (pp) and a particle $p_1$ in the central region. The pomeron and the reggeon exchange from both the (pp) vertex and virtual-photon vertex meet in the common central vertex at $p_1$. The four-momentum of $p_1$ in the central region is small and the four-momentum of $p_2$ is of the same order as the target $p$. Here $\nu \to \infty$, $\nu_1 \to \infty$, $k_1 \to \infty$, $k_2$ finite and $\nu_1 k_1 / \nu = c$ (say) finite:

$$\begin{align*}
\frac{2(2p \cdot q + q^2)}{4\pi \nu} p_1^0 p_2^0 \frac{d\sigma}{d^3 p_1 d^3 p_2} \to \sum_{i,j} \nu_{i1} k_{1i} \nu_{j1} \nu_{i1} \nu_{j1} (Q^2) \beta_{\gamma i j} \beta_{\gamma i j} \left( \frac{\nu_1 k_1}{\nu} \right) \beta_{\gamma i j} \left( \frac{\nu_2}{\nu} k_2 \right).
\end{align*}$$

Here $\alpha_i$ and $\alpha_j$ are intercepts of Regge trajectories, while the $\beta$'s are residue functions. The requirement of scaling for the deep inelastic structure functions $m W_i(q^2, \nu)$ and $v W_i(q^2, \nu)$ leads to the following $Q^2$-dependence of the photon-reggeon coupling (5):

$$\begin{align*}
\beta_{\gamma i j} (Q^2) \propto \left( \frac{1}{Q^2} \right)^{\alpha_i} \beta_{\gamma i j}.
\end{align*}$$

Therefore we have in the scaling region

$$\begin{align*}
\frac{2(2p \cdot q + q^2)}{4\pi \nu} p_1^0 p_2^0 \frac{d\sigma}{d^3 p_1 d^3 p_2} \approx \left( \frac{\nu}{\nu_0} \right)^{x i j - 1} \frac{\beta_{\gamma i j} \beta_{\gamma i j}}{(Q^2)^{\alpha_i} \beta_{\gamma i j} \beta_{\gamma i j} (c)} \beta_{\gamma i j} \left( \frac{\nu_2}{\nu} k_2 \right).
\end{align*}$$

We consider here only the leading-pomeron trajectory for large $\nu$. The invariant cross-section in both Regge and scaling region is independent of $\nu$. The correction $O(\nu^{-1})$ for $\nu$ not too large will come from nonpomeron trajectories.
