Hard Vector Meson photoproduction with rapidity gaps

contributed by I. F. Ginzburg

We consider the production of vector mesons on a quark or gluon. The cross sections for the quasi-real $\gamma^* p$ processes with rapidity gap are obtained by the standard convolution with structure functions. Let $\hat{s}$ be the squared c.m.s. energy for the $\gamma^* q$ collision, $p_\perp$ - the transversal momentum of the produced meson or photon in this frame, and $\eta \approx \ln(\hat{s}/p_\perp^2)$ - the rapidity gap (from the meson to the quark or gluon). It is assumed that $\hat{s} \gg p_\perp^2, Q^2$, $p_\perp^2 \gg \mu^2 = (0.2 \div 0.3 \text{ GeV})^2$.

A. γ and light vector mesons production with $Q^2 < p_\perp^2$.

I. Hard Compton effect $\gamma q \to \gamma q$ with $Q^2 = 0$[1] [1, 2]

$d\sigma/dp_\perp^2 \propto (1/p_\perp^4) F(s/p_\perp^2)$ for $p_\perp > p_{pert} \approx 1 \div 1.2$ GeV. The overall coefficient is given by the basic two–gluon approximation. $F \approx 1$ for $\eta < 3$. The BFKL enhancement is expected for higher η. For $p_\perp > 2 \div 3$ GeV one can see a specific azimuthal dependence relative to electron scattering angle.

II. $\gamma q \to V q$ with $Q^2 < p_\perp^2$ [1, 2, 3].

The produced light mesons will be polarized longitudinally for $p_\perp > p_{hel}$, where $p_{hel}(Q^2 = 0) \approx 1.5 \div 2.5$ GeV for ϕ, ≈ 5 GeV for ρ. The value of p_{hel} decreases with increasing virtuality. $d\sigma/dp_\perp^2 \propto (1/p_\perp^6) F_1 F(s/p_\perp^2)$ for $p_\perp > p_{pert} > p_{hel}$. The overall coefficient is given by the basic two–gluon approximation and F_1 depends strongly on the ratio $(Q^2/p_\perp^2)$. For $\eta < 3.5$ we expect that F_1 is given by the two-gluon approximation and $F \approx 1$. Observation of higher values of η with BFKL enhancements seem to be difficult for HERA experiments.

The quantity p_{pert} decreases fast with photon virtuality: $p_{pert}(Q^2 = 0) \approx 6 \div 8$ GeV for ϕ, $\approx 7 \div 10$ GeV for ρ; $p_{pert}(Q^2 = 2.25) \approx 1.5 \div 2$ GeV for both ϕ and ρ. The region $p_\perp > p_{pert}$ seems beyond access of the experiments at HERA for real photons but is observable at HERA for moderate virtualities.

B. $\gamma q \to V q$ for $Q^2 > p_\perp^2$ (all vectors) and **heavy mesons $(J/\Psi, \Upsilon, ..)$** for any $p_\perp$.

All vector mesons will be longitudinally polarized at $Q^2 > p_\perp^2$. The heavy mesons will be polarized transversally at $Q^2 < M^2$. The BFKL enhancement is expected but the argument in $\ln(\hat{s}/?)$ is not predicted within modern pQCD [2, 4].

What can be tested:

A. *pQCD in pure form*:

a) longitudinal polarization of light V's at $p_\perp > p_{hel}$;

b) $p_\perp^2$ dependence for light V's and photons at $p_\perp > p_{pert}$, $\eta < 3.5$;

c) strong $u = Q^2/p_\perp^2$ dependence at $p_\perp > p_{pert}$, $\eta < 3.5$ for small u;

d) *BFKL pomeron in pQCD* at $p_\perp > p_{pert}$, $\eta > 3.5$. The opportunity to see pure BFKL at $p_{pert} > p_\perp > p_{hel}$ should be studied;

e) *scales of nonperturbative effects* – positions of p_{hel} and p_{pert}.

B. *pQCD* in the polarization dependence. *BFKL + additional hypothesis about the argument in the* $\ln(s/?)$ *dependence.*

[1] The experimental difficulties are obvious, special work related to the extraction of this process compared with bremsstrahlung is necessary.

References

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