Abstract

We give a brief overview on the present status of Generalized Vector Dominance as applied to vector-meson production and the total photoabsorption cross section in the region of small $x_{bj}$. We comment on how GVD originates from QCD notions such as color transparency.

† Presented at the 7th International Workshop on Deep Inelastic Scattering and QCD, DESY-Zeuthen, April 19-23, 1999
1 THE BASIC QUESTION

Concerning DIS at low values of the scaling variable, $x_{bj}$, a basic question has been around for about thirty years [1]: when does the virtual photon behave hadronlike, is it when $Q^2 \to 0$ or is it when $x_{bj} \to 0$, but $Q^2$ fixed and arbitrarily large? Here, “hadronlike” behaviour includes the transition of the (virtual) photon to (massive) $q\bar{q}$ states and their subsequent diffractive forward scattering from the proton, in generalization of the role of the low-lying vector mesons in photoproduction. There is qualitative experimental evidence for this picture of generalized vector dominance (GVD) [2] at low $x_{bj}$ and large $Q^2$,

i) the existence of high-mass diffractive production discovered at HERA [3],

ii) the similarity in shape (thrust, sphericity) [4] of the states diffractively produced in DIS and the ones produced in $e^+e^-$ annihilation,

iii) the persistence of shadowing in $\gamma^*A$ collisions for $x_{bj} \to 0$ at fixed $Q^2 >> 0$ [5].

Quantitatively, one starts [2] from the mass dispersion relation for $\sigma_T(W^2, Q^2)$,

$$\sigma_T = \int dm^2 \int dm'^2 \rho_T(W^2, m^2, m'^2)m^2m'^2 \frac{(Q^2 + m^2)(Q^2 + m'^2)}{(Q^2 + m^2)^2}$$

and its generalization to the longitudinal photon absorption cross section, $\sigma_L$, where the spectral weight function is related to the product of the $\gamma^*q\bar{q}$ transition (in the initial and the final state in the forward Compton amplitude) and the imaginary part of the $q\bar{q}$ proton forward scattering amplitude. Frequently, the diagonal approximation, $\rho \sim \delta(m'^2 - m^2)$, is adopted that requires $\sigma_{q\bar{q}p} \sim 1/m_{q\bar{q}}^2$ to obtain scaling for $\sigma_T$.

2 DIAGONAL GVD

Lack of space does not permit me to reproduce the phenomenologically successful representation of $\sigma_{\gamma^*p}(W^2, Q^2)$ at low $x_{bj}$, including photoproduction, by GVD. I have to refer to ref. [6]. The diagonal approximation, nevertheless, cannot be the full story. After all, diffraction dissociation exists in hadron reactions, and there is no particular reason in a gluon-exchange picture that would forbid different masses, $m_{q\bar{q}} \neq m'_{q\bar{q}}$, for ingoing and outgoing $q\bar{q}$ states in the forward Compton amplitude.
Reformulating and extending the off-diagonal GVD ansatz \cite{ref7} for elastic vector meson production, recent work \cite{ref8} by Schuler, Surrow and myself yields a satisfactory representation of the transverse cross section and the longitudinal-to-transverse ratio, $R$, for elastic $\rho^0$, $\phi$ and $J/$Psi-production \cite{ref8}. The theoretical prediction for $\sigma_{T,\gamma^*p\rightarrow Vp}$ is based on

$$\sigma_{T,\gamma^*p\rightarrow Vp} = \frac{m_{V,T}^4}{(Q^2 + m_{V,T}^2)^2} \sigma_{\gamma p\rightarrow Vp}(W^2).$$

(2)
I refer to ref. [8] for the prediction for $R$. The inclusion of off-diagonal transitions with destructive interference yields $m_{V,T}^2 < m_V^2$, where $m_V$ stands for the mass of the vector meson being produced. As an example, in fig. 1, I show $\phi$ production. The curves (2-par. fit) are based on $m_{\phi,T}^2 = 0.40m_\phi^2$ and $\sigma_{\gamma p\to\phi p} = 1.0\mu b$. The theoretical curves for $J/$Psi production in fig. 2 were obtained by the replacement $m_\phi^2 \to m_{J/$Psi$}^2$ and $\sigma_{\gamma p\to\phi p} \to \sigma_{\gamma p\to J/$Psi$ p}$.

4 OFF-DIAGONAL GVD FROM QCD

This is work in progress in collaboration with Cvetic and Shoshi [9]. Starting from the QCD notion of color transparency [10] and an impact-parameter representation for $\sigma_{\gamma p}^{tot}$, we obtain a representation for $\sigma_{\gamma p}^{tot}$ of the form (1). The spectral weight function turns out to be much like the one conjectured a long time ago [11]. Color transparency, as fulfilled in a two-gluon exchange ansatz, provides the destructive interference necessary [11] for convergence and scaling in (1), thus resolving what has sometimes been called [12] the “Gribov paradox”.

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