Low x_{bj} DIS, QCD and Generalized Vector Dominance

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We give a brief overview on the present status of Generalized Vector Dominance as appplied 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.

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 $\sigma_T(W^2, Q^2)$,

$$\sigma_T = \int dm^2 \int dm'^2 \frac{\rho_T(W^2, m^2, m'^2) m^2 m'^2}{(Q^2 + m^2)(Q^2 + m'^2)}, \quad (1)$$

and its generalization to the longitudinal photon absorption cross section, σ_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 $\sigma_{q\bar{q}p} \sim 1/m^2_{q\bar{q}}$ to obtain scaling for σ_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.

3. OFF-DIAGONAL GVD IN VECTOR-MESON PRODUCTION

Reformulating and extending the off-diagonal GVD ansatz [7] for elastic vector meson production, recent work [8] by Schuler, Surrow and myself yields a satisfactory representation of the transverse cross section and the longitudinal-to-transverse ratio, R, for elastic ρ^0, ϕ and J/ψ-production [8]. The theoretical prediction for $\sigma_{T,\gamma^* p \to Vp}$ is based on

$$\sigma_{T,\gamma^* p \to Vp} = \frac{m^4_{V,T}}{(Q^2 + m^2_{V,T})^2} \sigma_{\gamma p \to Vp}(W^2). \quad (2)$$

I refer to ref.[8] for the prediction for R. The inclusion of off-diagonal transitions with destructive interference yields $m^2_{V,T} < m^2_V$, where m_V stands for the mass of the vector meson being produced. As an example, in fig.1, I show ϕ production. The curves (2-par. fit) are based on

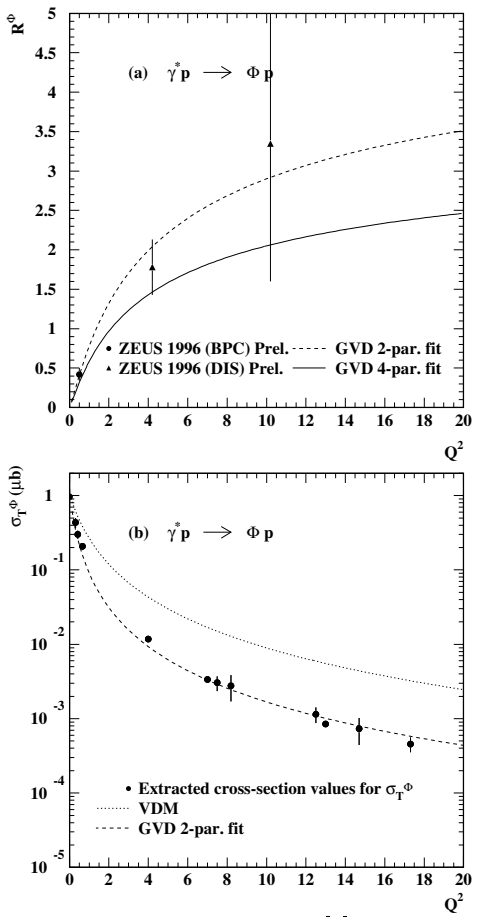

Figure 1. GVD in $\gamma^* p \to \phi\ p$ [8].

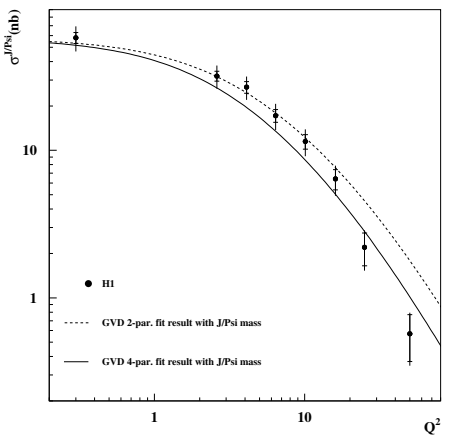

Figure 2. GVD in $\gamma^* p \to J/\psi\ p$.

$m^2_{\phi,T} = 0.40 m^2_\phi$ and $\sigma_{\gamma p \to \phi p} = 1.0 \mu b$. The theoretical curves for J/ψ production in fig.2 were obtained by the replacement $m^2_\phi \to m^2_{J/\psi}$ 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 $\sigma^{tot}_{\gamma^* p}$, we obtain a representation for $\sigma^{tot}_{\gamma^* p}$ 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".

REFERENCES

1 Proc. of the 1971 International Symposium on Electron and Photon Interactions at High Energies, ed. by N.B. Mistry, Cornell University 1972, p. 295.

2 J.J. Sakurai and D. Schildknecht, Phys. Lett.**B40** (1972) 121; B. Gorczyca and D. Schildknecht, Phys. Lett. **B47** (1973) 71.

3 H1 Collab., T. Ahmed et al., Nucl. Phys. **B429** (1994) 477; ZEUS Collab., M. Derrick et al., Phys. Lett. **B315** (1993) 481.

4 ZEUS Collab. results, presented by R. Wichmann at DIS98, Brussels, April 1998.

5 J. Achiman et al., EM Collab., Phys. Lett. **B202**, (1998) 603; M. Arnedo, Phys. Reports **240**, (1994) 301.

6 D. Schildknecht and H. Spiesberger, hep-ph/9707447; D. Schildknecht, Acta Physica Polonica **B11**, (1997) 2453; hep-ph/9806353.

7 H. Fraas and D. Schildknecht, Nucl. Phys. **B14**, (1969) 543; H. Fraas, B.J. Read and D. Schildknecht, Nucl. Phys. **B88**, (1975) 301.

8 D. Schildknecht, G.A. Schuler and B. Surrow, Phys. Lett. **B449** (1999) 328; hep-ph/9810370.

9 G. Cvetic, A. Shoshi and D. Schildknecht, in preparation.

10 e.g. N.N. Nikolaev and B.G. Zakharov, Z. Phys. **C49** (1991) 607.
11 H. Fraas, B.J. Read and D. Schildknecht, Nucl. Phys. **B86** (1975) 346.
12 J.D. Bjorken, hep-ph/9601363.