- 1

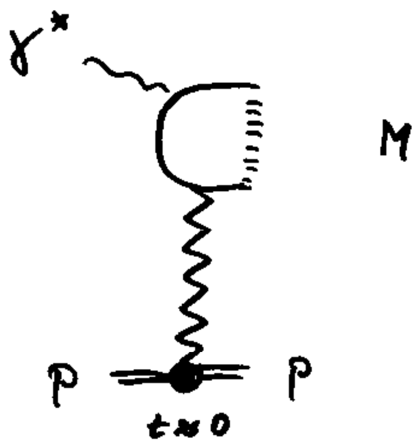
DIS 97, Chicago April '97
J. Bartels

Higher Twist in

Diffractive Dissociation

Motivation for studying higher twist in DIS diffr. dis

Experimental evidence that



contains also "hard Pomeron": $\gamma^*_L p \to V p$, $\gamma^* p \to \text{jets} + p$.

How to separate "soft" and "hard" components in the integrated diffractive cross section: by

expansion in powers of $1/Q^2$ ("twist expansion")

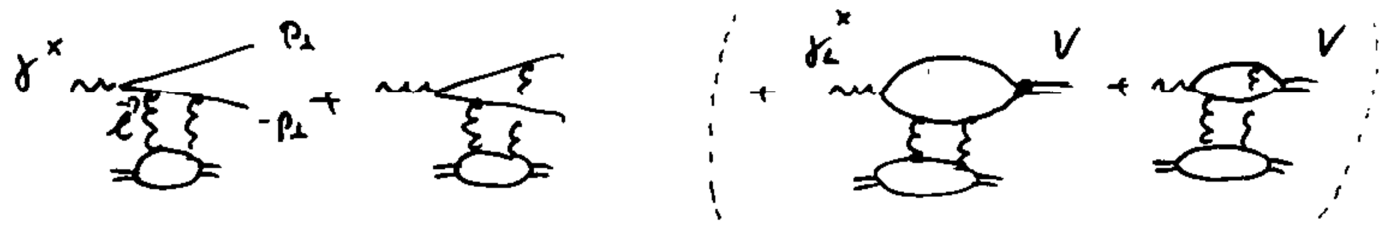
$$\frac{d^4\sigma}{dx\, dQ^2\, dx_{P}\, dt}\Big|_{t=0} = \frac{4\pi\alpha_{em}}{x Q^4} \cdot$$

$$\cdot \left\{ \frac{1+(1-y)^2}{2} \Big(F_T^D + \underset{?}{\frac{m^2}{Q^2}} \Delta F_T^D \Big) + (1-y) \Big(\underset{?}{F_L^D} + \frac{m^2}{Q^2} \Delta F_L^D \Big) \right\}$$

How to adress this question:

- $q\bar{q}$ production (reliable for small masses, $\beta \to 1$)
- $q\bar{q}(ng)$ in the region $Q^2 \ll M^2 \ll W^2$

A. Diffractive $q\bar{q}$- production:



Start from large-$p_\perp$ region where pQCD is applicable and extrapolate down to finite/small $p_\perp^2$:

JTS, Ellis, Kowalski, Wüsthoff

$$\left.\frac{d\sigma_T}{dM^2\, dp_\perp^2\, dt}\right|_{t=0} \approx \sum_f e_f^2 \frac{\alpha_{em}\pi^2\alpha_s^2}{3} \frac{1-\frac{2p_\perp^2}{M^2}}{\sqrt{1-\frac{4p_\perp^2}{M^2}}} \frac{4M^4Q^4}{(M^2+Q^2)^6} \left[x_P\, g\left(x_P, \frac{p_\perp^2}{1-\beta}\right)\frac{1}{p_\perp^2}\right]^2$$

Integral over $p_\perp^2$ (at fixed β): dominance of small $p_\perp$;
AJM configuration; $(1-\beta)$ factor.
Expect soft (nonperturbative) Pomeron

Expand in powers of $1/Q^2$:

leading-twist: nonperturbative, needs model assumption Buchmüller et al
e.g. unintegrated gluon structure function

$$\phi \sim \frac{1}{k_0^2}\left(\frac{k_0^2}{l^2}\right)^{\nu(\Delta)}, \quad \nu \sim \begin{cases} 1 & \text{large quark virtuali} \\ 0 & \text{small} \; \text{"} \quad \text{"} \end{cases}$$

nonplanar diagram << planar diagram:

→ picture of Pomeron structure function emerges

$$\left.\frac{d^2\sigma_T}{dt\,dM^2}\right|_{t=0} \sim \frac{1}{Q^6}\,\beta^3(1-\beta)\,\left[x_P\, g(x_P, \frac{Q^2}{4\beta})\right]^2$$

- large $\vec{l}^2$, but no $\log Q^2$
  calculable in pQCD
- vanishes as $1-\beta$
- enhancement due to square of gluon structure function
  " hard Pomeron contribution "

The same for the longitudinal cross section:

$$\left.\frac{d\sigma_L}{dM^2 dp_\perp^2 dt}\right|_{t=0} \approx \sum e_f^2 \frac{\alpha_{em}\pi^2\alpha_s^2}{3}\frac{4}{\sqrt{1-\frac{4p_\perp^2}{M^2}}}\frac{Q^2(Q^2-M^2)^2}{(M^2+Q^2)^6}\frac{1}{p_\perp^2}\left[x_P\, g(x_P, \frac{p_\perp^2}{1-\beta})\right]^2$$

Integral over $p_\perp^2$: no enhancement at small $p_\perp$
Expansion starts with higher twist (twist 4)
no twist-2 contribution

Twist-4 term:

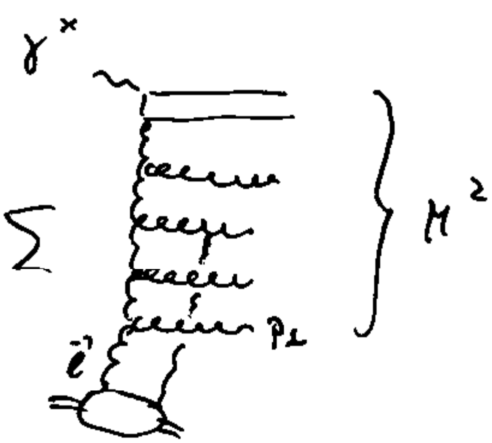
$$\left.\frac{d^2\sigma_L}{dt\,dM^2}\right|_{t=0} \sim \frac{1}{Q^6}\,\ln Q^2/4\beta \cdot \left[x_P\, g(x_P, \frac{Q^2}{4\beta})\right]^2$$

- extra $\log Q^2$, strong ordering in transverse momenta
  e.g. $l^2 \ll p_\perp^2 \ll Q^2$; calculable in pQCD
- nonvanishing at $\beta = 1$
- enhancement due to square of gluon structure function: " hard Pomeron contribution ".

JB, Wüsthoff, Lotter

Q^2 - evolution

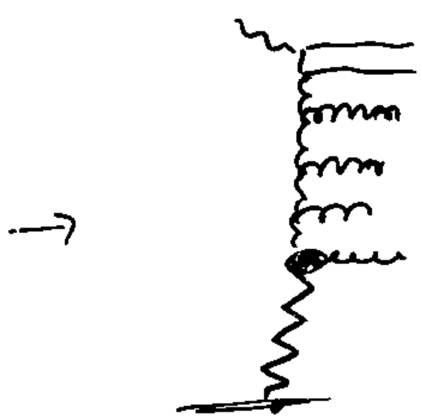
Arguments based upon $\gamma^* p \to \underbrace{(q\bar{q} + ng)}_{M^2} / p$, in the region $Q^2 < M^2$ (small β)



Leading-twist:

- soft $\vec{l}^{\,2}$ $\to$ nonperturbative Pomeron
- DGLAP - evolution

Soper, Berera
Kunszt



Kwiecinski et al
Golec-Biernat + Stirling
H1
Capella et al
..

Twist-4: very different characteristics

- $\langle \ln \frac{\vec{\ell}_\perp^{\,2}}{Q_0^2} \rangle \sim \langle \ln \frac{Q^2}{Q_0^2} \rangle \cdot \xi(W^2,M^2)$, $\quad 0<\xi<1$

  → Pomeron ~ gluon structure function

  → calculable in pQCD!

Lipatov et al

- QCD evolution for twist 4: nonlinear DGLAP-splitting functions, new kernels

e.g. 

- interesting possibility:
  evolution equation has inhomogeneous term ≠ Le.. et al.

$$\frac{\partial f(\beta, q^2)}{\partial \ln q^2} = f_0(\beta, q^2) + (K \otimes f)(\beta, q^2)$$

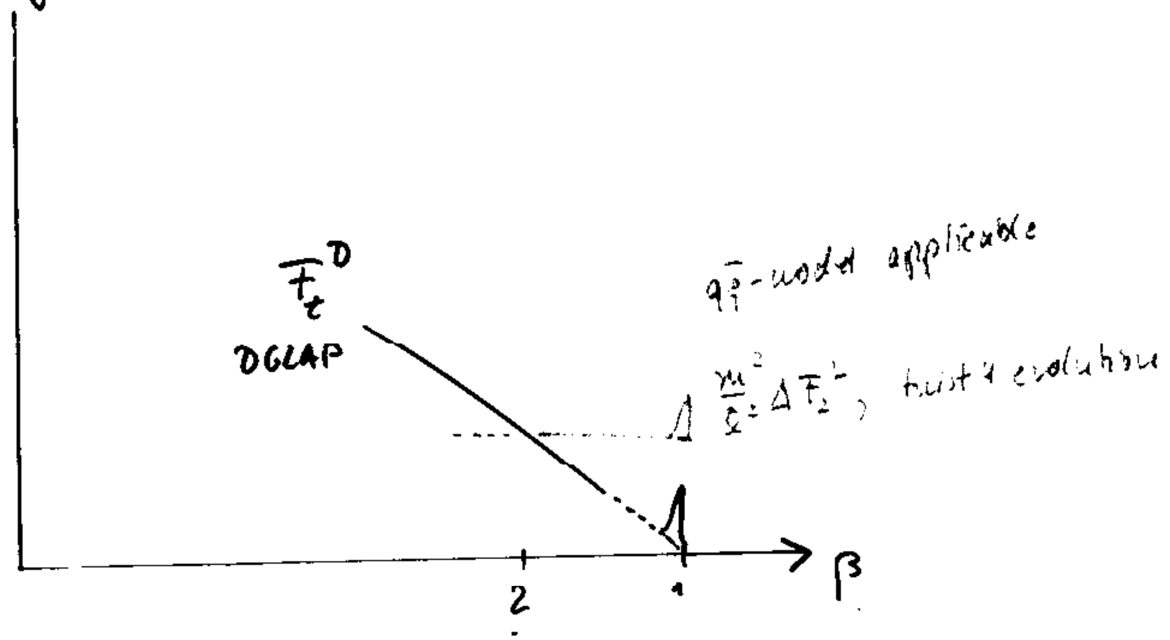
↑ $\sim [x_P\, g(x_P, q^2)]^2$

↑ twist-4 evolution kernels

(analogy with pointlike photon?)

- need to calculate twist-4 evolution kernels and mixing of twist-4 operators

Summary: expect



- $1/Q^2$ -expansion good tool for separating "soft" and "hard" components in F^D

- twist-4 visible in F_2^D near $\beta=1$

- analysis of data should include F_L, higher twist, in particular near $\beta = 1$. → Wüsthoff's talk