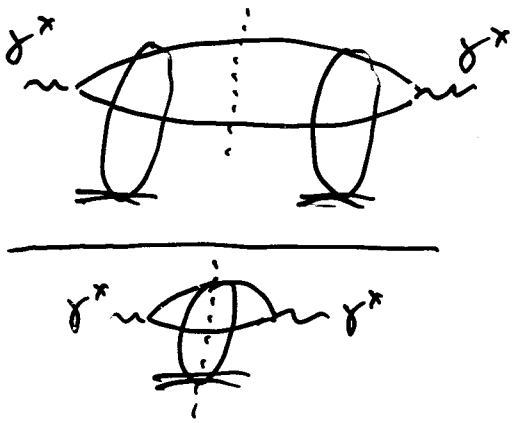
Saturation (GBW): (for $q\bar{q}$)



$r > 2R_0(x)$

$r < 2R_0(x)$

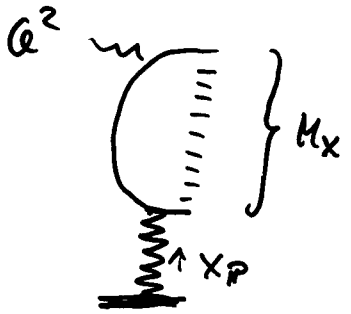
: varies weakly with W^2 (logarithmic)

subtle manifestation of saturation!

Conclusion: (personal)

- appealing physical picture (simple, consistent with QCD) explains different phenomena
- cannot convince those who do not believe

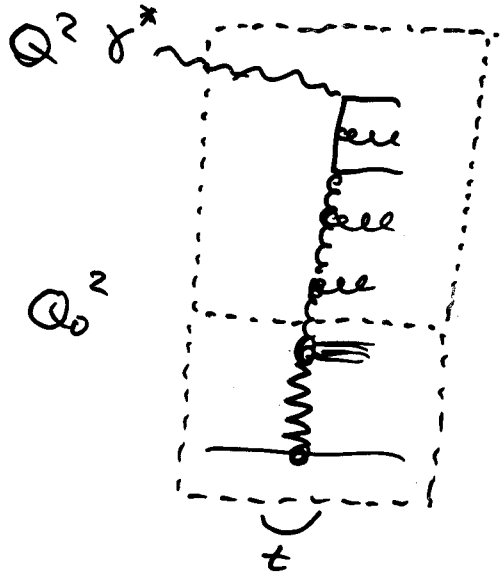
4) Diffractive parton densities:



$$\beta = \frac{Q^2}{M^2 + Q^2}, \quad x_B = \beta x_P$$

$$d\sigma \sim f(x_P)\, F_2^D(\beta, Q^2)$$

Q^2-variation: DGLAP evolution (Factorization theorem)



pQCD

initial conditions

Result:

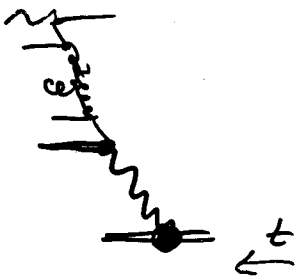
- new fits to diffractive PDF's
- effective $\alpha_{eff}(t) = \alpha_{eff}(0) + \alpha' \cdot t$

$$\alpha_{eff}(0) > \alpha_{soft} = 1.08$$

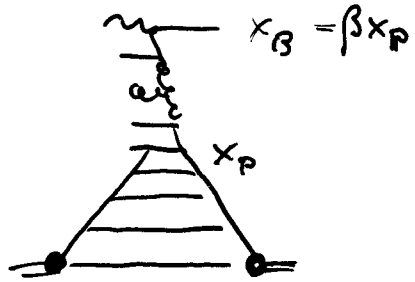
→ higher momentum scale in "Pomeron remnant"

Space time picture:

not:



but:
Pomeron is part of the proton

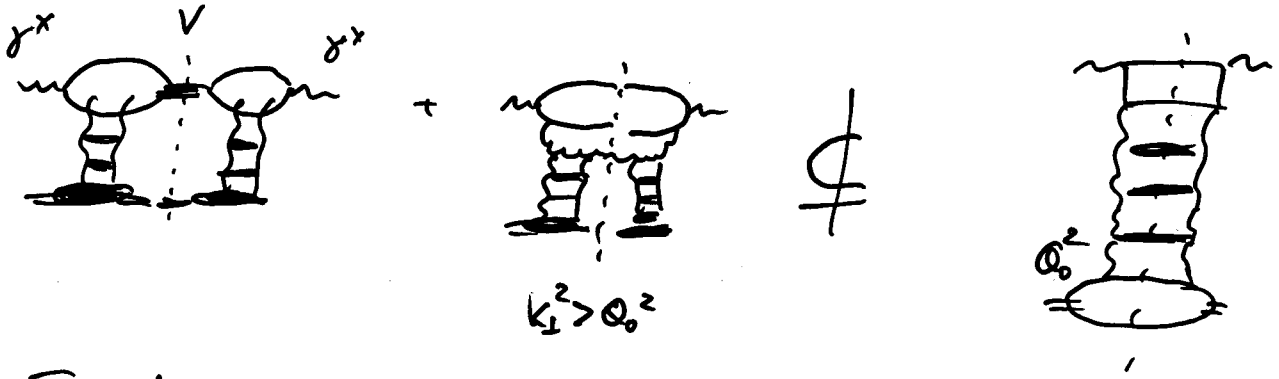


5. Diffraction and F_2

DIS diffraction is part of $\sigma_{tot}(\gamma^* p) = \frac{4\pi\alpha_{em}^2}{Q^2} F_2(x, Q^2)$.

But: does all diffractive cross section belong to leading-twist DGLAP?

Can diffractive cross section be used to estimate corrections to DGLAP?



Twist 4 for Long. Vector

$\mathcal{O}\left(\frac{1}{Q^2}, \frac{1}{k_\perp^2}\right)$ higher twist?

leading-twist

Attempt of quantitative estimate: Martin, Ryskin, Watt

perform global fit <u>after</u> removal of hard part of diffraction

→ gluon less negative, visible effect

→ not all diffraction belongs to leading-twist DGLAP

Comment on higher twist: not large / small in F_2

$F_2 = F_L + F_T$: partial cancellation of twist 4 in F_2

may explain small higher twist in F_2

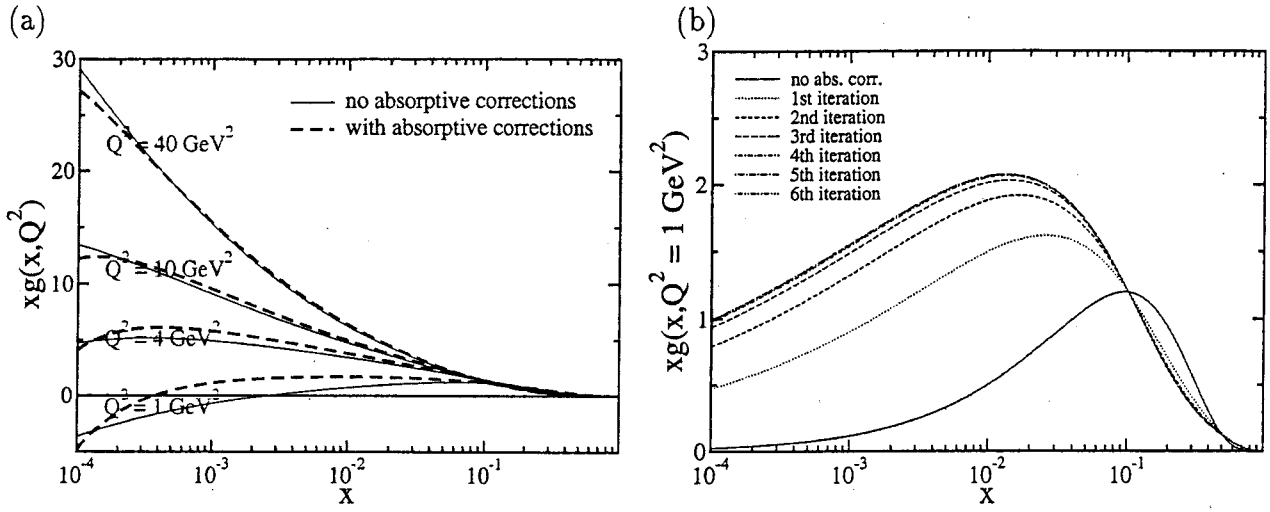


Figure 3: (a) The gluon distribution obtained from fits to F_2 data, before and after absorptive corrections have been included. (b) The effect of successive iterations on the gluon distribution obtained from fits to F_2, taking a positive definite input gluon at 1 GeV. Each iteration introduces another level of $2 \to 1$ Pomeron mergings.

fairly rapid, with only the first three iterations having a significant effect, that is, the 'fan' diagrams which include $8 \to 4 \to 2 \to 1$ Pomeron mergings.

Although we have seen that the inclusion of absorptive corrections has reduced the need for a *negative* gluon, it has not solved the problem of the *valence-like* gluon. That is, the gluon distribution at low scales still decreases with decreasing x, whereas from Regge theory it is expected to behave as $xg \sim x^{-\lambda_{\rm soft}}$ with $\lambda_{\rm soft} \simeq 0.08$. We have studied several possibilities of obtaining a satisfactory fit with this behaviour [13]. The only modification which appears consistent with the data (and with the desired $\lambda_g = \lambda_S$ equality) is the inclusion of power-like corrections, specifically, a global shift in all scales by about 1 GeV^2. (Note that a similar shift in the scale is required in the dipole saturation model [22].) However, we do not have a solid theoretical justification for this shift. Therefore, a more detailed, and more theoretically-motivated, investigation of the effect of power corrections in DIS is called for.

Acknowledgements

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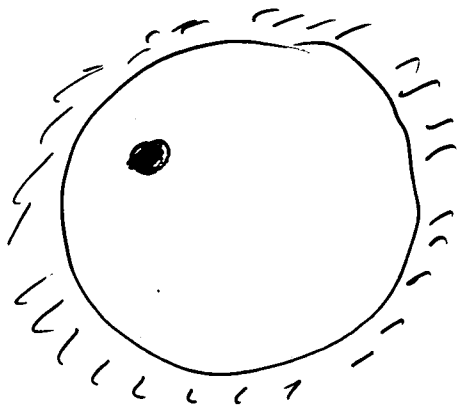
References

[1] L. V. Gribov, E. M. Levin and M. G. Ryskin, Phys. Rept. **100** (1983) 1.

Conclusion: $\gamma^* p$, (quasi) elastic

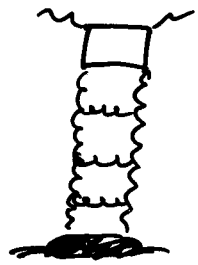


- Partly computable [energy, Q^2-dependence]
- " nonperturbative (Radii, α'_{eff})
- physical picture for transition (saturation)

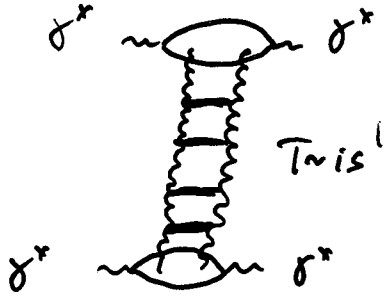
V. Beyond Ladder Exchanges: Reggeon Field Theory; AGK rules

Ladder diagrams:

DGLAP evolution

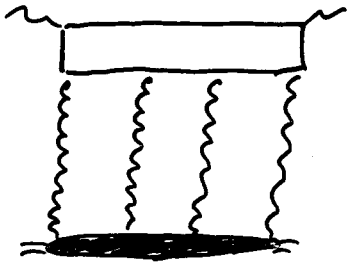


BFKL:

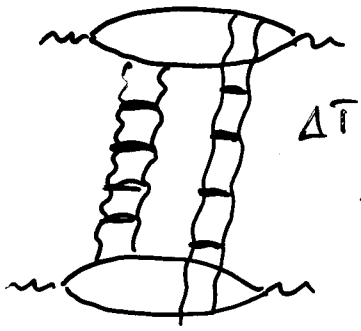


$T \sim s^{1+\omega_{BFKL}}$

Beyond:



BFKL



$\Delta T \sim -i\alpha_s^2 \cdot s^{1+2\omega_{BFKL}}$

Higher twist: $\frac{1}{Q^2}\Delta F_2(x, Q^2)$

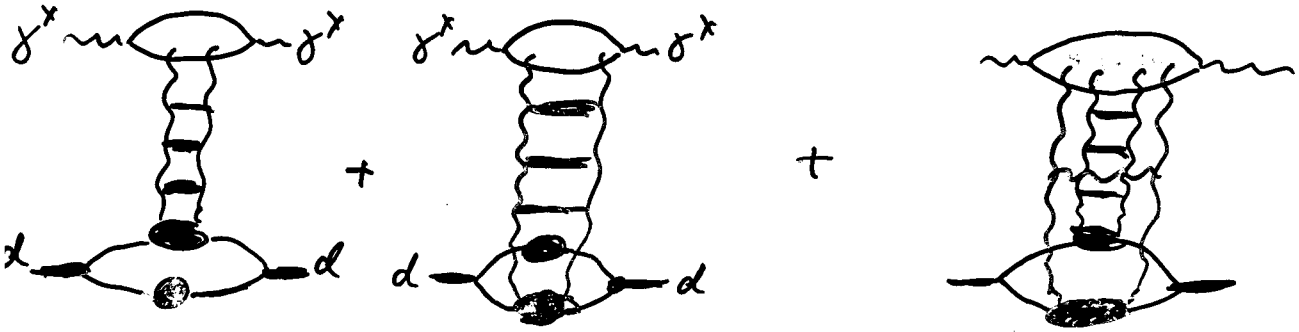
→ at small x (large s) need to consider

Find systematics (for BFKL approach)

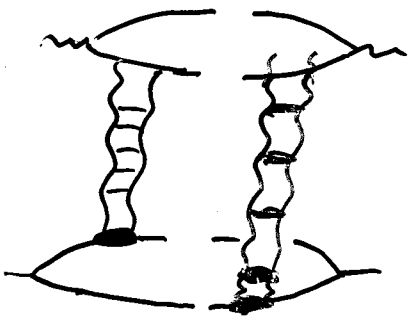
Complementary to other approaches

DIS on deuteron: consider $\gamma^* d \to \gamma^* d$, use optical theorem

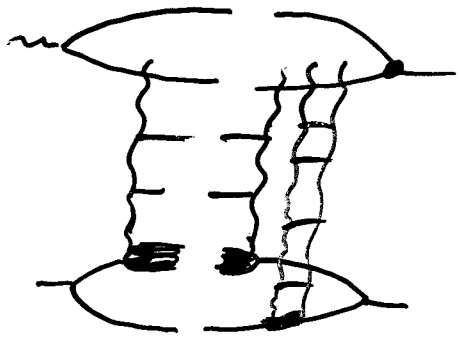
d = weakly bound state of p and n



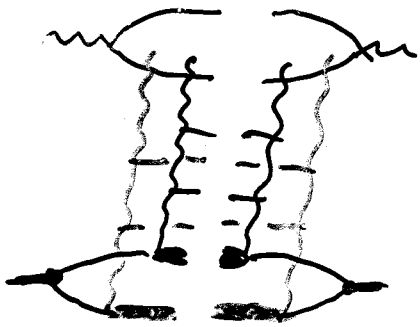
3 different contributions: (see later)



diffractive



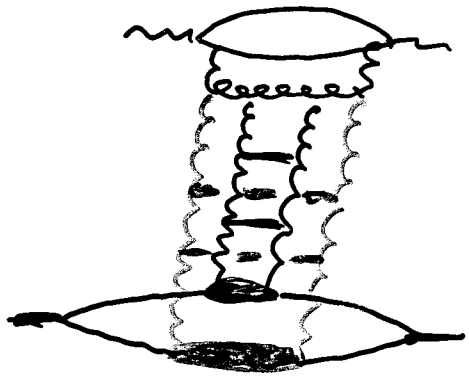
absorption



double cut

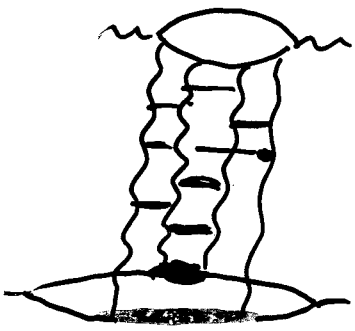
Generalizations:

(a)



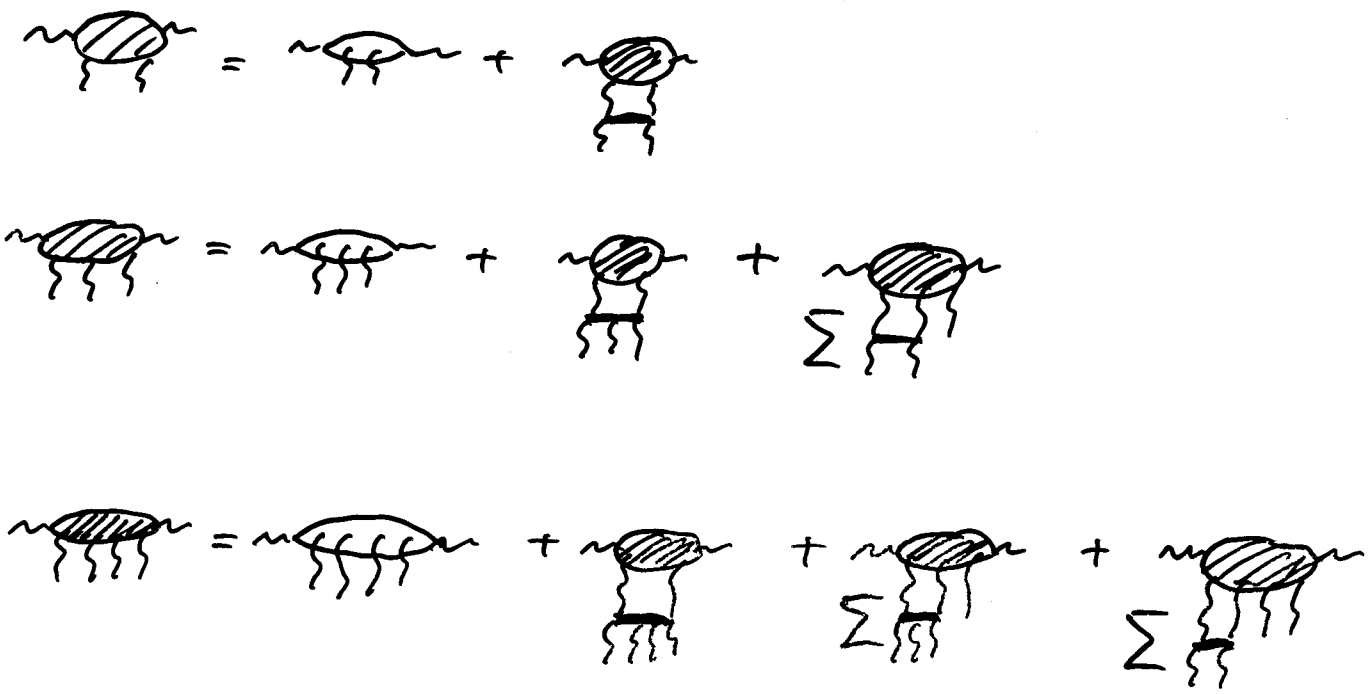
$\gamma^* \to q\bar{q} + ng$

(b)



ladders loose identity

[but: large N_c helps!]

(c) Integral equations:

coupled set of equations for gluon correlators