AGK Rules in pQCD

Abramovsky, Gribov, Kancheli
Sov. J. Nucl. Phys. 18, 308 (1974)

JB, M. Ryskin, Z. Phys C 76, 241 (1997)

JB, Kowalski, Lublinski, Sabio-Vera
in progress

Significance of AGK in Low-x physics

How does AGK work in pQCD

AGK at HERA, LHC

Significance of AGK in Low-x Physics

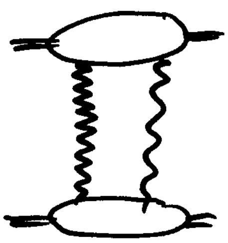
Which question does AGK address:

- at high energies (small-x), finite t:
  Regge-physics (Pomeron exchange)

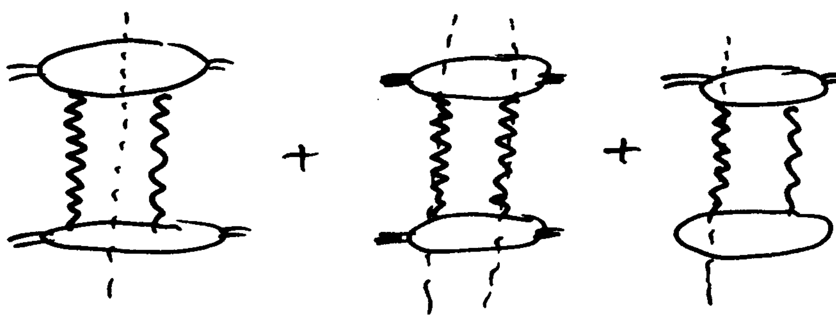
- how does scattering amplitude T contribute to cross section (e.g. σ_{tot}):
  imaginary part, discontinuities

Simplest case: two Pomeron exchange

$T_{2\to2} \sim$



$\mathrm{Im}\, T_{2\to2}$:



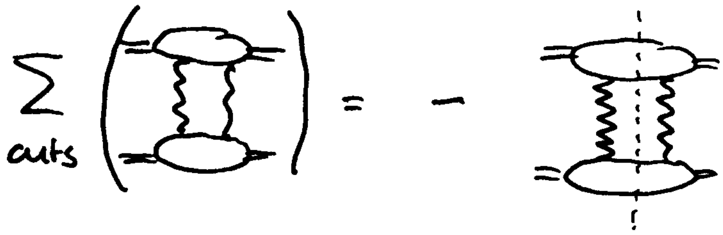
+ c.c.

+1   +2   −4

"diffractive"   "double-cut"   "absorptive"

Consequences:

- simple relation between diffraction and sum of all contributions:



- signals in final states

  fluctuations on particle density

- correlations in rapidity

$$\frac{d^2\sigma}{dy_2\,dy_1} - \frac{1}{N}\frac{d\sigma}{dy_1}\frac{d\sigma}{dy_1} \quad , \quad N = \sigma_{tot}$$

Where could this be of interest:

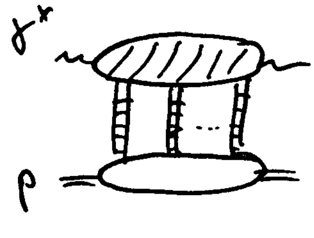
A. HERA: Saturation at low x and small Q^2

So far: indirect evidence only for saturation

- success in description of F_2
- natural explanation of scaling
- energy dependence of diffraction $\sigma^{diff}(W^2)$

→ look for more direct evidence

Idea: all saturation models are based upon "sum over multiple exchanges"

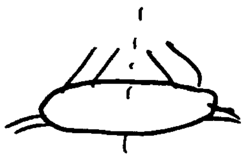
$\sigma^{\gamma^* p} \sim \sum_n$ 

alternating sign, represents sum over all cuts

Goal:
" Open the saturation model"
Look for features of final state
Monte Carlo for parton production

} AGK: "cut QCD-ladders"

Key quantities: multiparton correlators

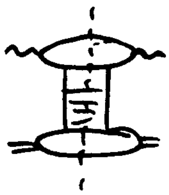
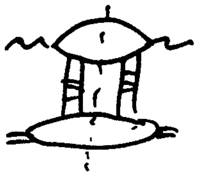
e.g.  , 

Could be estimated (determined?) from successful saturation model!

Can they be transported to pp-scattering?

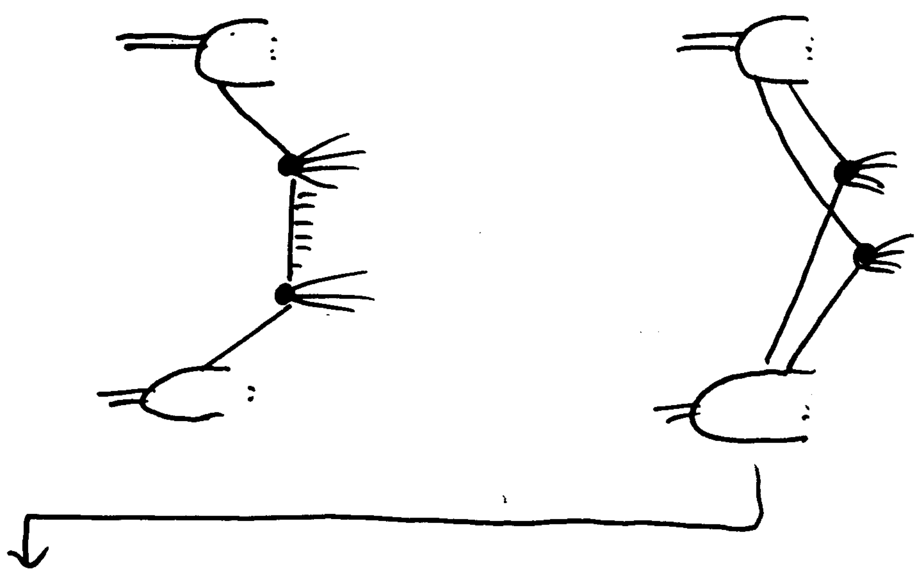
First step: Two-ladder exchange in DIS

Diffraction vs. DGLAP: Lund Martin, Ryskin

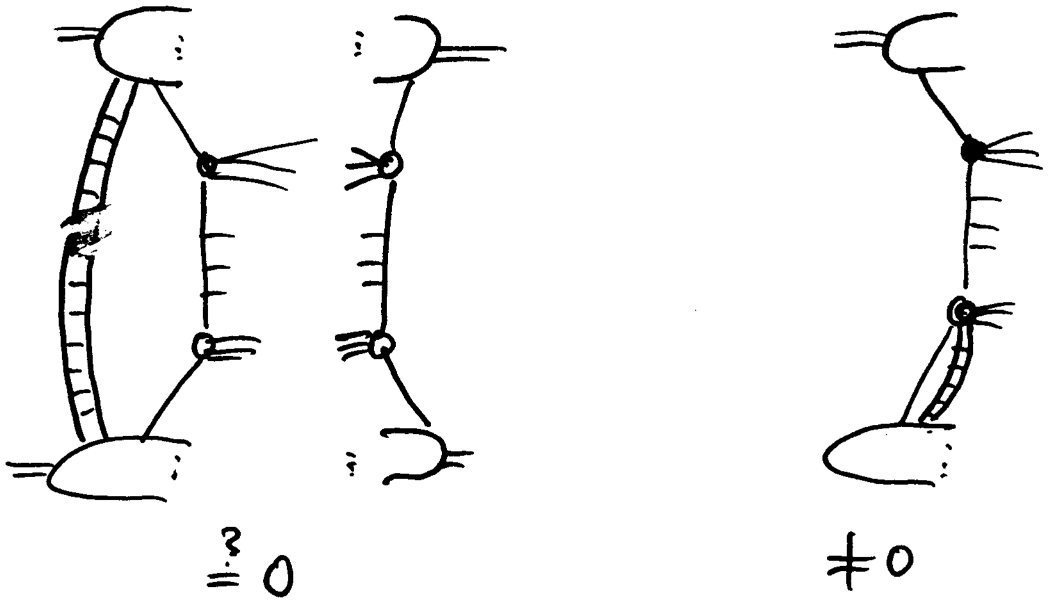
  + other cuts

B. LHC : multiple interactions   Lund

Multiple jet pair-production, e.g.



Connected with:



all connected via counting rules + calculations

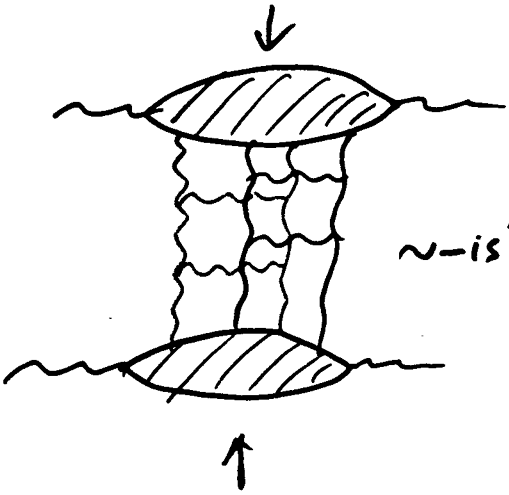
HERA-analysis could provide input !

How Does AGK work in pQCD?

Two-Pomeron exchange: $\gamma^*\gamma^* \to \gamma^*\gamma^*$

how to cut the amplitude

$T_{\gamma\gamma^*}$:

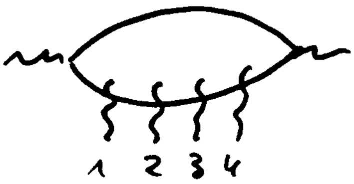


$\sim -is^{1+2\omega_{BFKL}}$

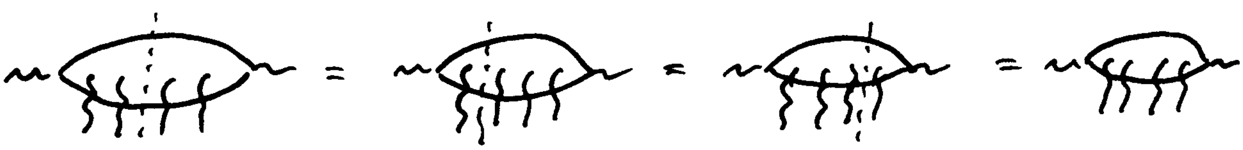
t-channel view!

at high energies: color singlet ladders dominate

Basic properties:

-  symmetry in (1234), color + momenta

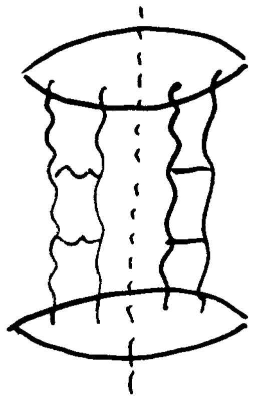
- "cut = uncut":



- not cut across vertical gluon

 forbidden (suppressed in energy)

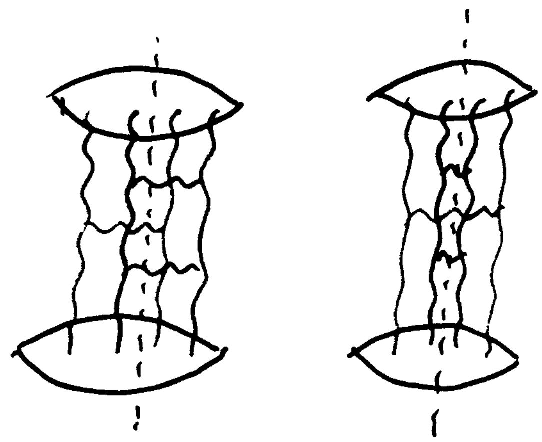
Two cuts:



$\frac{1}{2!}$ $\frac{1}{2!}$

diffractive

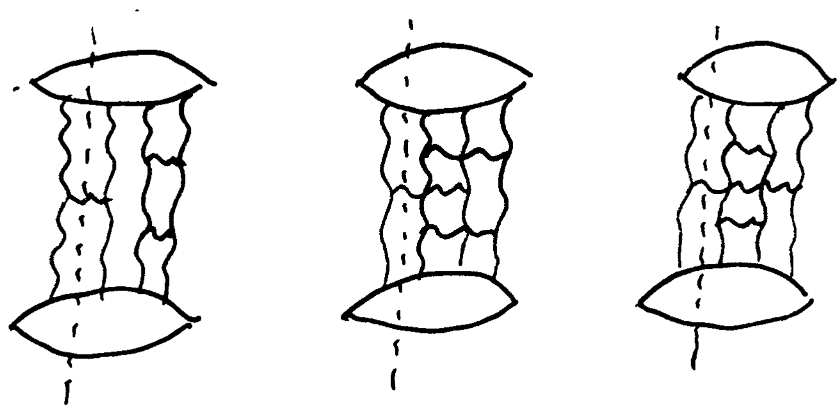
$\frac{1}{4} \cdot 1$



$\frac{1}{2!} \cdot \frac{1}{2!}$ $\frac{1}{2!} \cdot \frac{1}{2!}$

double cut

$\frac{1}{4} \cdot 2$



+ c.c.

absorptive

$-3 \cdot \frac{1}{3!} = -\frac{1}{2}$ $-3 \cdot \frac{1}{3!} = -\frac{1}{2}$

$-\frac{1}{4} \cdot 4$

→ agrees with AGK

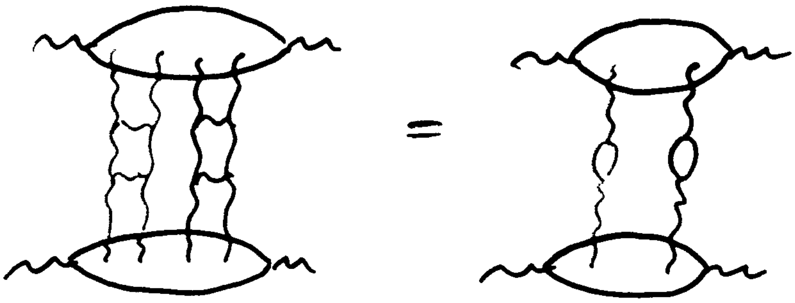
Generalization straightforward: for example

m ladders ($=2m$ gluons), $k<m$ cut:

$$\text{weight factor} = (-1)^{m-1} \frac{1}{m!} \frac{m!}{k!(m-k)!}$$

But: "QCD has color"

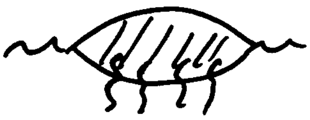
pairs can be in octett



= BFKL

satisfies also AGK, but $\sim s^{1+\omega_{BFKL}}$

Therefore:

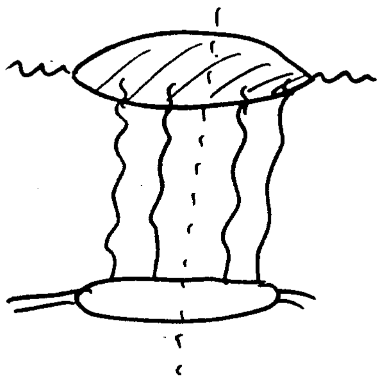


contains several contributions

- antisymmetric color octet pieces
  - → corrections to single ladder
- symmetric pieces
  - → color singlet most interesting ones.

AGK at HERA, LHC

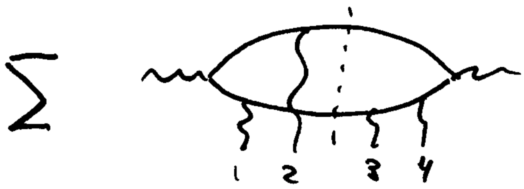
Return to two-ladder contribution:



Theoretical issues:

a) photon side:

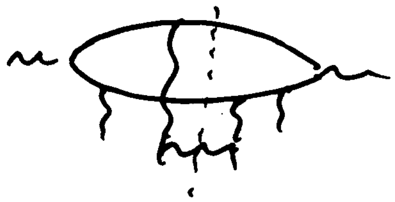
lowest order: quark loop



contains symmetric and antisymmetric pieces

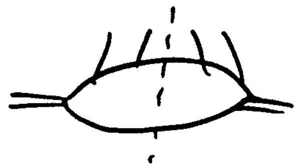
Color singlet projection in (12) and (34) is not enough to symmetrize

→ diffractive cross section contains a piece which does not "participate in AGK"

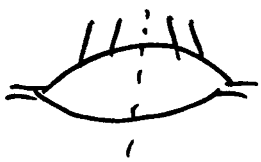
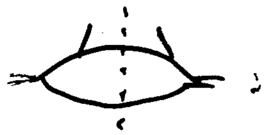
Σ 

fully symmetric piece emerges

→ fulfills requirements of AGK

b) Proton side: assume that 

4-gluon correlator has the same symmetry structure as suggested by pQCD

Strength of  relative to :

within a given model (GBW, ...) fixed by global fit to F_2.

c) transport results to LHC: prediction for multiple scattering (at small x).

Conclusion

- We know how AGK works in QCD
(presence of color degree of freedom makes things a bit more complicated)

- test saturation at HERA:
need for Monte Carlo which respects AGK counting rules

- transport to LHC
"HERA gift for LHC"