A Baryonic Impact Factor

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Helsinki, August 2007

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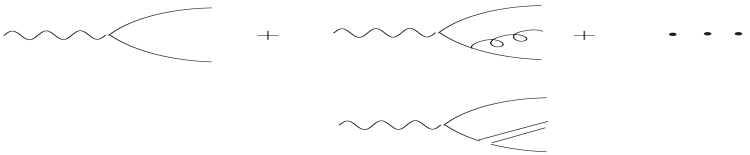
- Decomposition of the Impact Factor
- Evolution
- Conclusions

Collaboration with Leszek Motyka

Introduction

Very popular: color dipole picture (large-N_c), much used in DIS:



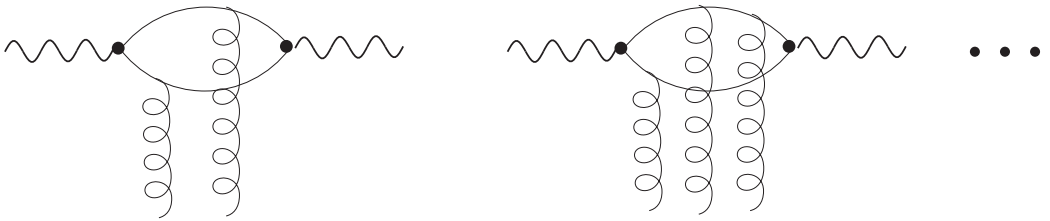
Question: how much of the dipole picture can be used in hadron-hadron (hadron-nucleus) scattering? Obviously:

- proton is 3 quark state - not a dipole
- In large-N_c: proton would be N_c-quark state

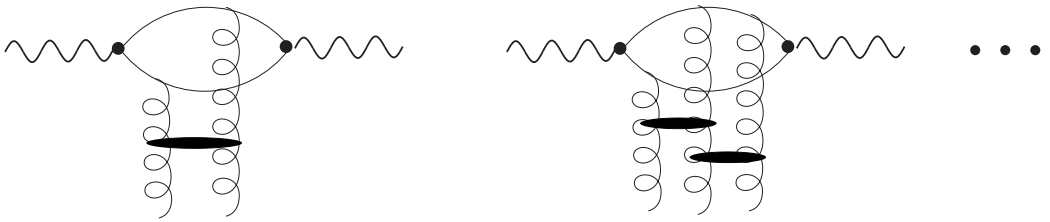
About ten years ago (Praszalowicz,Rostworowski)):
Problem with color dipole picture for the proton,
'Each step in rapidity evolution creates new color state'

Two steps: baryon impact factor and evolution.
How to address: t-channel approach, BFKL approximation.

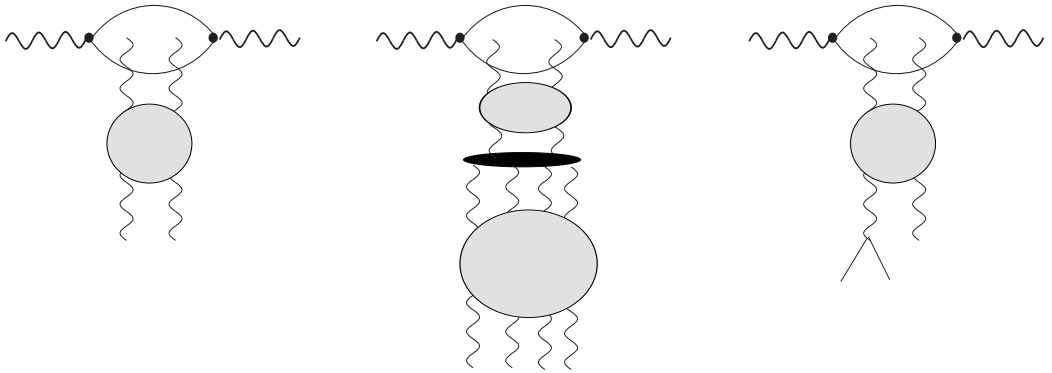
Impact factor:



Gluon emission $\longrightarrow$ evolution:



In the photon case one finds a remarkable simplification: fan-like structure



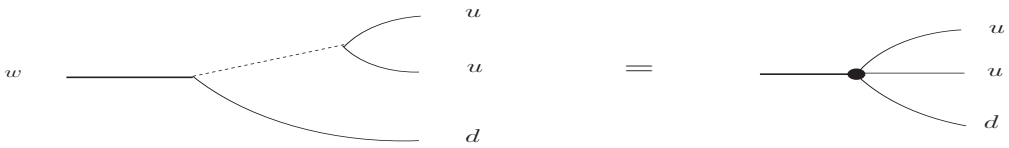
Contains elastic unitarity: reggeization, bootstrap.

Large N_c: BK equation.

In the following: apply the same analysis to a baryonic impact factor.

The baryon wave function

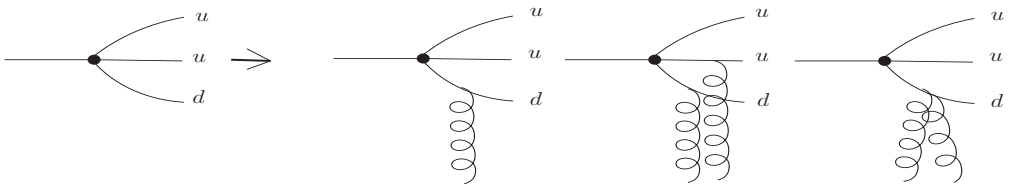
A few technicalities:
start from 4-Fermi operator (Ioffe):



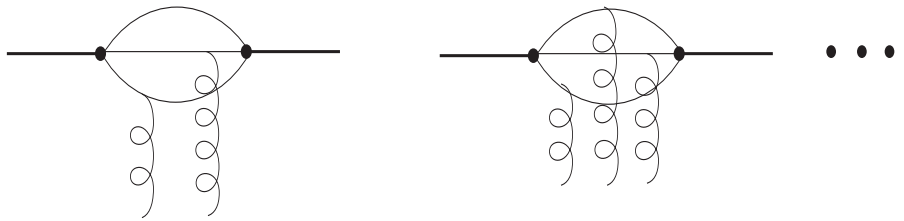
$$\epsilon_{abc} u(x)^{a\,T} C\gamma^{\mu} u(x)^{b}\ w(x)\gamma_5\gamma_\mu d(x)^{c}$$

More realistic: include nonperturbative wave function.

Use helicity basis, infinite momentum frame, eikonal approximation:



Square, sum over helicities, compute color traces, sum over all possibilities of attaching gluons:

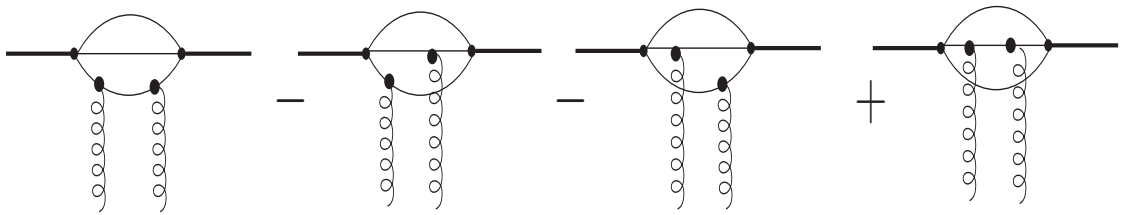


Results:

decompose the impact factor into irreducible (under evolution) pieces.

Decomposition of the impact factor

A.Two Gluons (C even): 'normal' dipole structure. The pair (23):

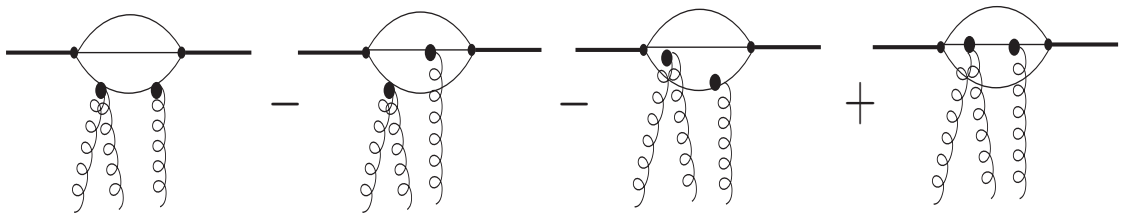


Dipole structure, but lines 2 and 3 are in antitriplet.
'Antitriplet dipole'
Contains diquark configuration, depends upon dynamics of wave function.

$$\left(D_{20}^{23}(k_1,k_2)+D_{20}^{13}(k_1,k_2)+D_{20}^{12}(k_1,k_2)\right)\delta_{ab}$$

Satisfies Ward identities.

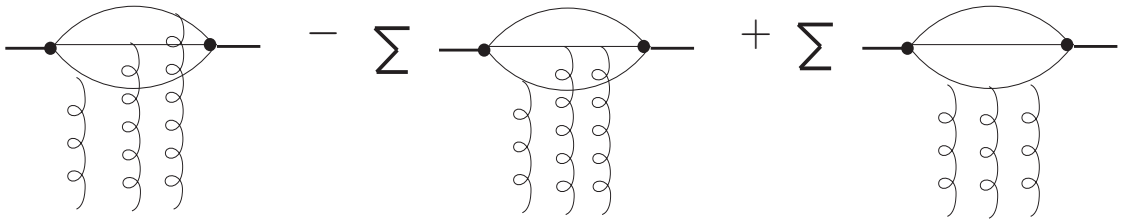
B. Three gluons (C even): reggeization of the 2 gluon system



$$\left(D_{20}^{23}(k_1+k_2,k_3)+D_{20}^{23}(k_1+k_3,k_2)+D_{20}^{23}(k_1,k_2+k_3)\right)f_{abc}+D_{20}^{12}+D_{20}^{13}$$

Reggeization + bootstrap, similar to photon impact factor.

Three gluons (C odd): Odderon (C.Ewerz)

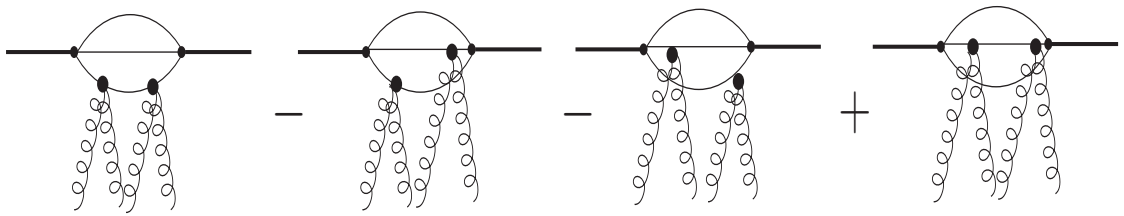


New function: $E_{30}(k_1,k_2,k_3)$. Satisfies Ward identities. Nonabelian charge configuration.

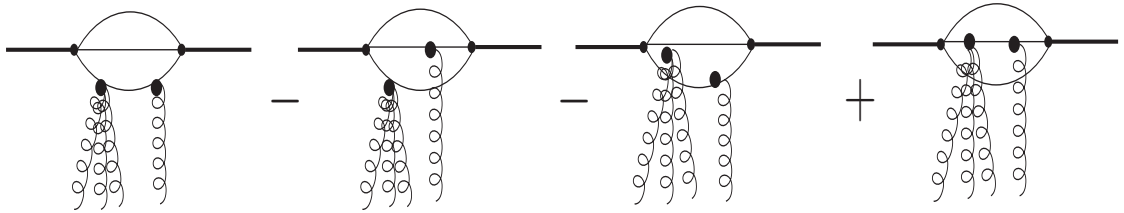
C. Four gluons (C even): different pieces

- reggeization of the 2 gluon system
- new configuration

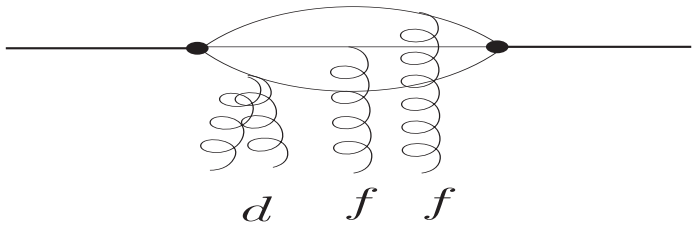
$D_{20}^{23}(k_1+k_2, k_3+k_4)$:



$D_{20}^{23}(k_1+k_2+k_3, k_4)$:



The new configuration: C even, even signature

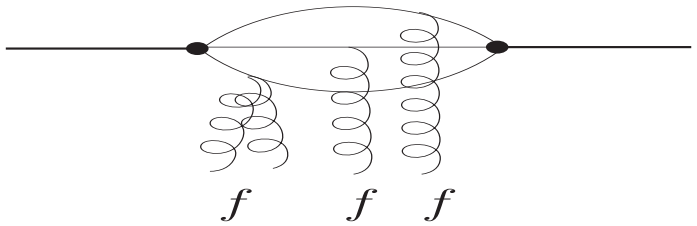


$+\ldots$

$$E_{30}(k_1+k_2,k_3,k_4)\left(d_{a_1a_2c}d_{a_1a_2c}-\frac{1}{3}\delta_{a_1a_2}\delta_{a_3a_4}\right)$$

Sum over all permutations satisfies Ward identities. Needs all 3 quarks.

Four gluons (C odd): reggeization of the odderon (C.Ewerz)



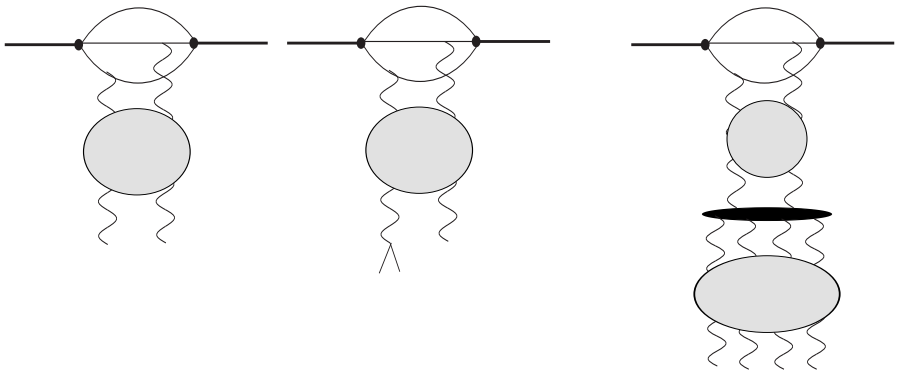
$+\ldots$

$$E_{30}(k_1+k_2,k_3,k_4)d_{a_1a_2c}f_{a_1a_2c}$$

Evolution, gluon radiation

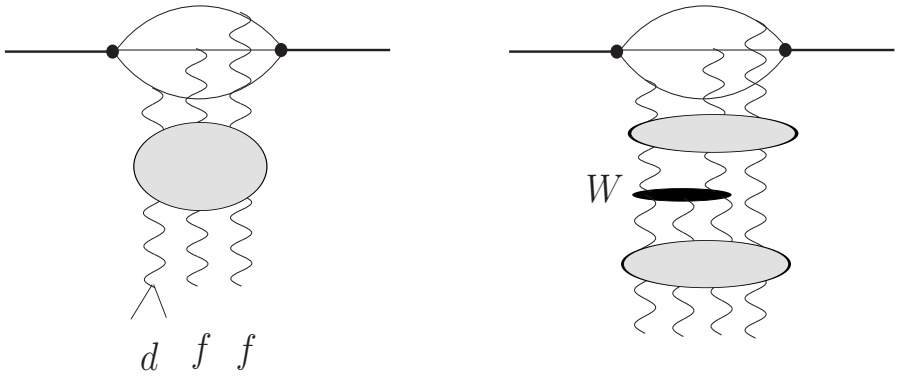
The decomposition of the impact factor is preserved under evolution.

Dipole-like term (color anti-triplet):



Looks like photon impact factor, fan structure... (BK equation?)
Contains the diquark configuration, but it also allows for spacial separation.

The new piece:
a new vertex appears (good properties, e.g. Möbius invariant):



s-channel picture: radiation from all three quarks, new evolution kernel.

In addition:
C-odd, Odderon: both the BLV and the WJ solutions couple.

Conclusions

Differences and similarities
between photon (=color dipole) impact factor and baryonic impact factor:

- Baryon contains 'antitriplet' dipole (diquark).
  From this dipole radiation as in the photon case.
- In addition: in the Pomeron channel odderon type evolution, with new kernel.
- in LO: no direct two-Pomeron coupling to the baryon (same as in the photon case)
- reggeization, bootstrap play an important role
- odderon-state mixes with Pomeron states, importance of d-reggeon
- QCD reggeon field theory is more than a theory of interacting BFKL Pomerons

Think about phenomenological applications.