Lessons from the high energy summation in Yukawa theories for modern description of diffractive processes.

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In the end of 60-th — beginning of 70-th we (A.V. Efremov, I.F.G. and V.G. Serbo) studied asymptotics of diagrams of Yukawa theory in diffractive limit

$$L = g\bar{\psi}\gamma^5\tau^i\psi\phi_i + \lambda(\phi_i^2)^2 \;\; at \;\; s \gg |t|, m_i^2 \,.$$

We summarize

ALL LOGARITHMIC CONTRIBUTIONS OF ALL DIAGRAMS

for scattering amplitude, assuming finite charge renormalization.

We use the Mellin transform of amplitude

$$F(j,t)$$

Contribution of each diagram is given by the sum $\sum a_k j^{-k}$.
We summarize all contributions having pole at $j = 0$.

The results were published in reviews

A.V.Efremov, I.F. Ginzburg, V.G. Serbo. Quantum field theory and Regge poles. *Proc. Int. Sem. on anal. properties of scattering amplitude, June 1969*, Serpuchov (1969).

A.V. Efremov, I.F. Ginzburg. Short distance scale invariance, high energy processes and elementary particles. *Fortschr. Physik* **22** (1974) 575-609.

Earlier publications were started from 1967

Main results
for amplitude with positive signature

1) LLA result

The amplitude obey equation

$$[f(j)]^2 - jf(j) - 4G_0^2(g,\lambda) = 0, \quad G_0^2(g,\lambda) = c_1 g^4 + c_2 \lambda^2 \;\Rightarrow$$
$$f_L(j,t) = v_0(j) = \frac{1}{2}\left(j \pm \sqrt{j^2 - G_0^2}\right)$$

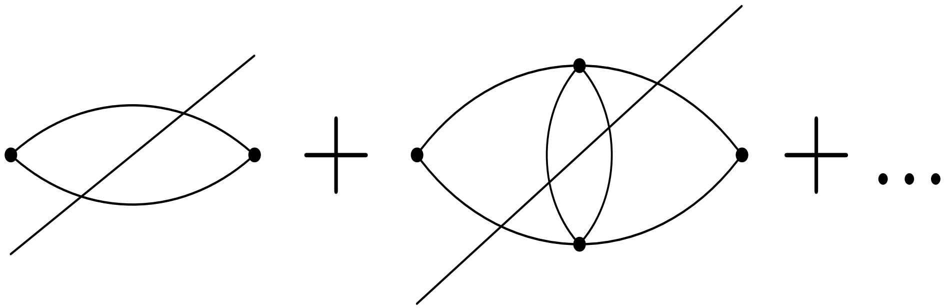
The LLA amplitude has immovable square root singularity in the j-plane at $j = G_0$, i.e. $f(s,t) \propto s^{G_0}(lns)^{-3/2}$

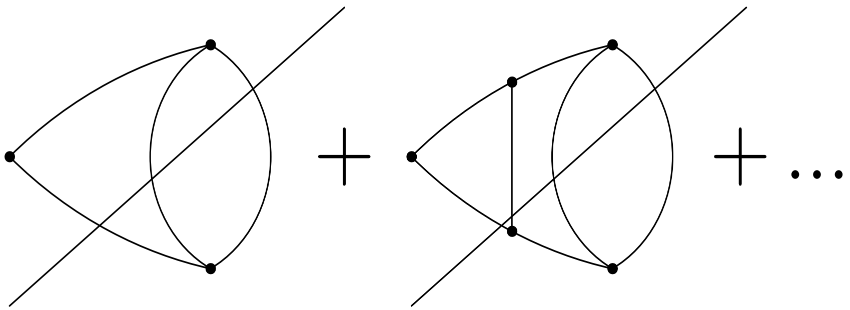
2) Complete amplitude

has both square root immovable singularity in j-plane and Regge poles:

$$F(j,t) = C_j^T(t) \frac{1}{v^{-1}(j) - B_j(t)} C_j(t)$$

where assuming finite charge renormalization the t-independent quantity $v(j)$ is similar to $v_0(j)$ but with the change $G_0 \to G = \psi(g,\lambda)$ with known diagrammatic representation for G^2. Variations of $v(j)$ for running coupling constants were almost evident based on approach from I.F. Ginzburg, V.V. Serebryakov. *Sov. Yad. Fiz.* **3** (1966) 164.
The t-dependent $B_j(t)$ and $C_j(t)$ have no singularities at $j > -1$. Their diagrammatic representations are

$B(t) =$ 

$C(t) = \cdot +$ 

We have here 3-vertexes $\bar{\psi}\psi\phi$ and 4-vertexes ϕ^4. The oblique strokes describe specific subtraction procedure.

Quantity $v(j)$ is described by small distance couplings, while $B(t)$, $C(t)$ are described by large distance effects.

Lessons

1) Complete amplitude has generally form, strongly different from that of LLA. In our example we cannot speak even what contribution is dominant in real amplitude, LLA similar immovable square-root singularity or Regge pole.

2) Improvements of LLA, similar to NLLA, NNLLA are often misleading. In our example they give corrected form for $v(j)$ and some general coefficient dependent on t instead of correct quit different behavior.

Odderon/ Pomeron

For the negative signature we had not so simple form of result.

Basics: There are two types of singularities of diagrams in j-plane,

• small distance singularities, appeared in both planar and non-planar diagrams;

• pinch singularities, obliged by both small and large distance effects, appeared in non-planar diagrams only.

For the considered class of theories we prove **THEOREM,** describing responsibility of different types of singularities for asymptotics of amplitude for summation of poles $(j - j_0)^{-n}$.

★ **at even j_0 (in particular, for $j_0 = 0$)**

• the amplitude with positive signature (Pomeron, P' trajectory) is described by only small distance singularities,

• the pinch contributions together with small distance are responsible for the amplitude with negative signature, – odderon

★ **at odd j_0 (in particular, for $j_0 = 1$)**

• the amplitude with negative signature (odderon) is described by only small distance singularities,

• the pinch contributions together with small distance are responsible for the amplitude with positive signature, – Pomeron, P' trajectory

In Yukawa theory for leading singularity $j_0 = 0$, in QCD $j_0 = 1$.

That is the reason for simple form of asymptotics of Pomeron in Yukawa theory and very complex BFKL Pomeron (LLA) in QCD. The Odderon in QCD must be more simple than odderon. It demands new, independent consideration, starting from diagrams. The representation odderon= colored Pomeron+gluon looks for us misleading.

THE END