Some application of Reggeon Lagrangian

E.A. Kuraev[a]
[a] *JINR, Dubna, 141980, Russia*

June 5, 2007

Perturbative QCD (PQCD) was sucessfully applied for description of inclusive production of hadron jets. Quantitative agreement between data and theory predictions has been achived for jet produced over a wide kinematical range. For instance data from Collider detector Fermilab (CDF,D0) on inclusve jet production for $\sqrt{s} = 1800GeV$ in agreement with PQCD predictions for jet transverse energy ranging from 15 up to 400 GeV.

Neverthelesss some problem arised when investigating the dependence of production cross section on the total energy. PQCD prediction on scaling violation involving Λ_{QCD}-QCD hadronic scale was found not to be consistent with data. In paper [1] was shown that existing data already contain evidence for additional non-PQCD effects which are consistent with the BFKL [4] Pomeron theory.

Recently [2] the Feynman rules for effective field theory base on non-abelian gauge- invariant action [5] were derived for the vertices of interaction of reggeized gluons R with gluons and quarks P of type $RP, RRp, RPP, RRPP, RRPPP, RPPPP$. These rules can be applyied for description of wide class of peripherical processes which can be studied on $\gamma\gamma, \gamma p, ep$ colliders as well as hadronic colliders CERN LEP2,LHC.

In the phenomenology of strong interactions at high energies it is necessary to to describe the QCD evolution of the gluon distribution function of the colliding particles starting from the scale μ_0,which control the non-perturbative region up to scale $\mu \sim \sqrt{M^2 + p_T^2}$ of the transverse mass of the produced particles. The procedure of resuming the contributions of sort $(\alpha_s \ln(s/\mu^2))^n$ can be done by adopting the high-energy factorization scheme [11], which also known as the k_T factorization approach. The incoming t-channel gluons are associated with a finite transverse momentum k_T and the relevant unintegrated gluon distribution function $\Phi(x, k_T^2, \mu)$. The resummation is then implemented by BFKL evolution equation [4]. Several types of Φ functions present in literature (see for instance [8] and references therein).

Cross section of processes of creation some hadron state with orbital momentum L,spin S, total momenntum J and color state a at hadrons collisions can be expresssed in form of conversion unintegrated gluon distributions functions Φ,associated with reggeized gluons with cross sections of relevant partonic subprocesses. The effective vertices of above mentioned type can be used to construct this partonic cross sections. In such a way the charmonium production was investigated in $pp, \gamma p, \gamma\gamma, e^+e^-, e\gamma$ colliders i paper [6]. When constructing the partonic cross section the nonrelativistic QCD framework [7] is usually used.

In the case when initial particles are leptons the Weizsacker-Williams approximation was applied to evaluate the e^+e^- cross section from $\gamma\gamma$ ones introducing the additional conversion with $f_{\gamma/e}(y)$:

$$f_{\gamma/e}(y) = \frac{\alpha}{2\pi}[\frac{1+(1-y)^2}{y}\ln\frac{Q^2_{max}}{Q^2_{min}} + 2m_e^2 y(\frac{1}{Q^2_{min}} - \frac{1}{Q^2_{max}})]. \quad (1)$$

Peripherical kinematics at LHC can be investigated to find other manifestations of Regge ideas applied to hadron physics.

A great progress in theoretical investigations of peripherical hadron physics produce a series of predictions which can be checked in such a experiments.

Measuring the differential distributions in fragmentation region and in the pionization region will provide the possibility to check the predictions of effective Regge action theory [2]. I will mention some relevant topics.

The three Pomeron vertex which was examined as in phenomenological as well QCD theory approaches is one of central problems of physics of preipherical interactions. The rigorous restrictions on it's value was obtained in phenomenological applications in last decades of last century. Some theoretical approaches as well was done with rather wide spectrum of predictions[3], constructing Pomeron as a bound state of reggeized gluons.

A new one related with direct using Regge Feynman rules [2] can be constructed [**?**], using the relevant projection operators and vertices RP, RRP,which seems to much more simple expression.

A problem of Pomeron and Odderon intersepts, is as well one of long-standing ones. It can be measured in peripherical production of the neutral pseudoscalar mesons experiments. As for theoretical description the investigation including the radiative corrections to effective reggeon vertices is needed. Some work in this direction was done in papers [9].

Production of heavy glueball states wa poorly investigated as well experimentally and theoretically. The relevant cross sections can be constucted using $RRPP, RPPP$ vertices and projection operators on the states with spin zero and two [10].

Correlations of jets separated by rapidity gap. It can be arranged using the unintegrated gluon distribution Φ and effective Regge vertices, and introducing the new jet separating parameter $R = \sqrt{(y_1 - y_2)^2 + (\phi_1 - \phi_2)^2}$ with difference of rapidities $y_1 - y_2 = \ln \frac{s_{12}}{\sqrt{k_{1T}^2 k_{2T}^2}}$, and ϕ_i-the relevant azimuthal angles.

Thhe program of calculations or radiative corrections to effective vertices is in fact in the beginning stage [9]. Estimation of accuracy of theoretical predictions,arising from nonleading contributions.

Development of adequate approach to calculate the spin structure functions in deep inelastic electron-proton scattering for the region of small values of Bjorken parameter x. It was shown as a result of ten yeas work (see paper [12]) noneffectiveness of doublelogarithmical approximation [13].

Check of accuracy of the hypothesis of factorization in transversal momentum space [3].

References

[1] V. Kim, G. Pivovarov,Phys. Rev. D57 (1998),R1341.

[2] E.Antonov at. al Nucl.Phys. B721(2005),111.

[3] J.Bartels et al hep-ph/0608154.

[4] E. Kuraev, L. Lipatov, V. Fadin,Sov.Phys. JETP 44,443(1976); I. Balitsky and L. Lipatov, Sov.J.Nucl. Phys. 28,822(1978).

[5] L. Lipatov,Nucl.Phys. B452,369 (1995).

[6] B. Kniehl, D. Vasin, V. Saleev, hep-ph/0602179.

[7] G. Bodwin, E. Braaten and G. Lepage, Phys. Rev. D 51,1125 (1995); 55, 5853(E)(1997).

[8] M. Kimber,A. Martin and M. Ryskin,Phys.Rev.63,114027 (2001); J. Blumlein, Report No. DESY,95-121, (1995); H. Jung, and G. Salam, Eur.Phys.J. C 19, 351,(2001).

[9] S. Baranov,Phys. Rev. D 66, 114003 (2002); V. Fadin, M. Kotsky and L. Lipatov, Phys. Lett.B415, 97 (1997); D. Ostrovsky, Phys. rev. D 62, 054028 (2000).

[10] P. ko, J. Lee and H. Song, Phys. Rev. D 54, 4312 (1996).

[11] J. Collins and R. Ellis, Nucl. Phys. B360,31 (1991).

[12] S. Moch, J. Vermaseren and A. Vogt, Phys. Lett. B625, 245, (2005).

[13] B. Ermolaev, S. Manaenkov and M. Ryskin,Z. Phys. C69,259, (1996).