

# Lev Lipatov: three episodes

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1940 -2017

“Vitam regit fortuna, non sapientia”  
“Chance, not wisdom, governs human life”  
( *Cicero*)

## Live in numbers

- Number of papers: 160;
- Number of citations per one paper: 161;
- Number of citations: 26 169;
- Papers with citations  $> 3000$ : 2;
- Papers with citations 2000- 3000: 1;
- Papers with citations 1000- 2000: 5;
- Papers with citations 500 - 1000: 2;
- Papers with citations 250 - 500: 7;
- Papers with citations 100 - 250: 19;
- Papers with citations 50 - 100: 16;
- Reviews: 6;
- Books: 3;
  - B. L. Ioffe, V. S. Fadin and L. N. Lipatov, “*Quantum chromodynamics: Perturbative and nonperturbative aspects,*”: Camb. Monogr. Part. Phys. Nucl. Phys. Cosmol. 30 (2010);
  - L. N. Lipatov, “*The creation of quantum chromodynamics and the effective energy,*” Bologna, Italy: Univ. Bologna (1998) 367 p;
  - B. L. Ioffe, V. A. Khoze and L. N. Lipatov, “*Hard Processes. Vol. 1: Phenomenology, Quark Parton Model,*” Amsterdam, Netherlands: North-holland ( 1984) 340p.

## I. 1957 - 1967: Ph.D. student of Prof. Gribov

- 1957 - 1962: student of Physics Department at Leningrad (St.Petersburg) State University;
  - 1960: Prof. Braun and his informal seminars;
  - 1962: diploma thesis under Prof. Braun supervision;
- 1963: Landau Theory minimum exams: 2 mathematics, classical mechanics, classical electrodynamics, statistical physics, quantum mechanics ← Landau books, quantum electrodynamics ← Akhiezer and Berestetsky book

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- 1964 - 1967: PhD student of Prof. Gribov;
  - Two duties:
    - participate all seminars;
    - answer all questions that an experimentalist will ask you;
  - “deep water” method;
  - “Physics goes first”;
  - Lev’s luck;

## II. 1966-1972: DLA in QED ( Log Academy and its president)

**DLA:**  $A(s, t) = \sum C_N (\alpha_{\text{e.m.}} \ln s \ln t)^n$ ;  $\alpha_{\text{e.m.}} \ln s \ll 1$ ;  $\alpha_{\text{e.m.}} \ln t \ll 1$ ;  $\alpha_{\text{e.m.}} \ll 1$ ;

- V. G. Gorshkov, V. N. Gribov, L. N. Lipatov and G. V. Frolov, “Double logarithmic asymptotics of quantum electrodynamics,” Phys. Lett. 22 (1966) 671.
- V. G. Gorshkov, V. N. Gribov, L. N. Lipatov and G. V. Frolov, “Backward electron - positron scattering at high-energies,” Sov. J. Nucl. Phys. 6 (1968) 262 [Yad. Fiz. 6 (1967) 361].
- V. G. Gorshkov, V. N. Gribov, L. N. Lipatov and G. V. Frolov, “Doubly logarithmic asymptotic behavior in quantum electrodynamics,” Sov. J. Nucl. Phys. 6 (1968) 95 [Yad. Fiz. 6 (1967) 129].
- V. G. Gorshkov, L. N. Lipatov and M. M. Nesterov, “On  $j$ -plane singularities of  $e$ -minus muon-minus scattering amplitudes,” Yad. Fiz. 9 (1969) 1221.
- L. N. Lipatov and G. V. Frolov, “Some processes in quantum electrodynamics at high energies and small scattering angles,” Pisma Zh. Eksp. Teor. Fiz. 10 (1969) 399.
- 1968: Candidate Dissertation
- E. A. Kuraev and L. N. Lipatov, “Total cross-section for electron and muon pair production in colliding electron beams,” Pisma Zh. Eksp. Teor. Fiz. 15 (1972) 229.
- E. A. Kuraev, L. N. Lipatov, N. P. Merenkov and V. S. Fadin, “Radiative corrections to bremsstrahlung radiation at high energies,” Zh. Eksp. Teor. Fiz. 65 (1973) 2155.

**1. Sudakov variables:**  $k_\mu = \alpha p_{1,\mu} + \beta p_{2,\mu} + \vec{k}_T$ .

**2. Introducing unitarity and analyticity in perturbative calculations;**

**3. Lipatov, Kuraev(Khar'kov) and Fadin(Novosibirsk) got together;**

### III. 1972-1974: Gribov-Lipatov evolution in DIS, DGLAP and etc.

- Prophetic seminar: Gribov's paper and its remnants (the young lion shows his fangs);

Leading  $\text{Log}Q^2$  Approximation:  $F_2(x, Q) = \sum C_n(x) (\bar{\alpha}_S \ln Q^2)^n$ ;  $\bar{\alpha}_S \ln(1/x) \ll 1$ ;  $\bar{\alpha}_S \ll 1$ ;

- [3704] V. N. Gribov and L. N. Lipatov, "Deep inelastic  $e p$  scattering in perturbation theory," *Sov. J. Nucl. Phys.* 15 (1972) 438 [*Yad. Fiz.* 15 (1972) 781].
- [1204] V. N. Gribov and L. N. Lipatov, " $e^+e^-$  pair annihilation and deep inelastic  $e p$  scattering in perturbation theory," *Sov. J. Nucl. Phys.* 15 (1972) 675 [*Yad. Fiz.* 15 (1972) 1218].
- [1338] L. N. Lipatov, "The parton model and perturbation theory," *Sov. J. Nucl. Phys.* 20 (1975) 94 [*Yad. Fiz.* 20 (1974) 181].
- 1974: Doctor of Science Dissertation; 2015: EPS prize;

**DGLAP:** V. N. Gribov and L. N. Lipatov (1972); G. Altarelli and G. Parisi, *Nucl. Phys.* B126, 298 (1977); Y. L. Dokshitzer, *Sov. Phys. JETP* 46, 641 (1977), [*Zh. Eksp. Teor. Fiz.* 73,1216(1977)]

**Wikipedia:** DGLAP was first published in the western world by Altarelli and Parisi in 1977,[1] hence DGLAP and its specialisations are sometimes still called Altarelli-Parisi equations. Only later did it become known that an equivalent formula had been published in Russia by Dokshitzer also in 1977[2] and Gribov and Lipatov already in 1972.[3]

- N. H. Christ, B. Hasslacher and A. H. Mueller, "Light cone behavior of perturbation theory," *Phys. Rev. D* 6 (1972) 3543.

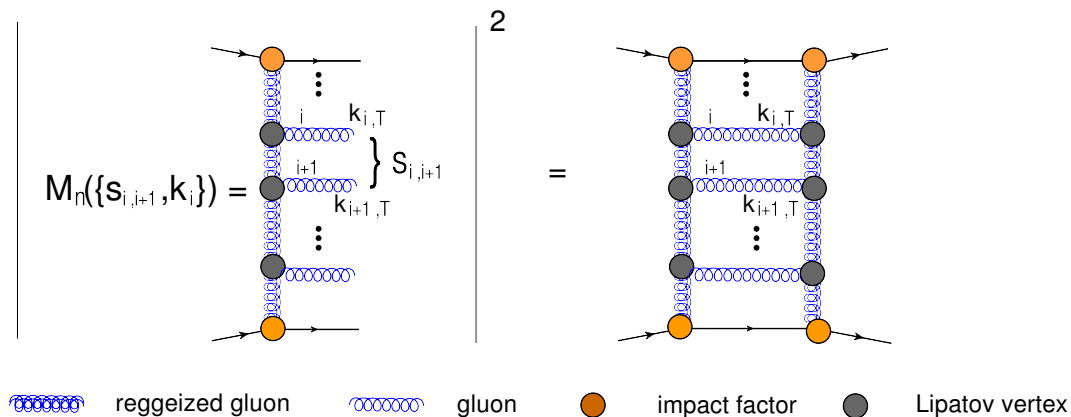
- Why Gribov and Lipatov did not calculate gluon decay kernel in 1975?

**Lev's answer:** Genya, I am close to understand the Pomeron structure in QCD and I do not have a student who can calculate it.

# 1975- 2017: Pomeron in QCD (BFKL Pomeron)

Leading Logs Approximation:  $A(x, t) = \sum C_n(t) (\bar{\alpha}_S \ln(s))^n$ ;  $\bar{\alpha}_S \ln(t) \ll 1$ ;  $\bar{\alpha}_S \ll 1$ ;

- [90,76] V. N. Gribov, L. N. Lipatov and G. V. Frolov, "The leading singularity in the  $j$  plane in quantum electrodynamics," Sov. J. Nucl. Phys. 12 (1971) 543 [Yad. Fiz. 12 (1970) 994]; Phys. Lett. 31B (1970) 34
- [1079] V. S. Fadin, E. A. Kuraev and L. N. Lipatov, "On the Pomernanchuk Singularity in Asymptotically Free Theories," Phys. Lett. 60B (1975) 50.
- [1181] L. N. Lipatov, "Reggeization of the Vector Meson and the Vacuum Singularity in Nonabelian Gauge Theories," Sov. J. Nucl. Phys. 23 (1976) 338 [Yad. Fiz. 23 (1976) 642].
- [1480] E. A. Kuraev, L. N. Lipatov and V. S. Fadin, "Multi - Reggeon Processes in the Yang-Mills Theory," Sov. Phys. JETP 44 (1976) 443 [Zh. Eksp. Teor. Fiz. 71 (1976) 840].
- [2985] E. A. Kuraev, L. N. Lipatov and V. S. Fadin, "The Pomernanchuk Singularity in Nonabelian Gauge Theories," Sov. Phys. JETP 45 (1977) 199 [Zh. Eksp. Teor. Fiz. 72 (1977) 377].
- [3292] I. I. Balitsky and L. N. Lipatov, "The Pomernanchuk Singularity in Quantum Chromodynamics," Sov. J. Nucl. Phys. 28 (1978) 822 [Yad. Fiz. 28 (1978) 1597].
- [868] L. N. Lipatov, "The Bare Pomeron in Quantum Chromodynamics," Sov. Phys. JETP 63 (1986) 904 [Zh. Eksp. Teor. Fiz. 90 (1986) 1536].
- [979] V. S. Fadin and L. N. Lipatov, "BFKL pomeron in the next-to-leading approximation," Phys. Lett. B 429 (1998) 127.
- 2001: **Pomernanchuk Prize**



# Conclusions:

- High energy QCD would be different without the BFKL Pomeron;
- High energy QCD will be different without Lev Lipatov;