Probing Balitsky-Fadin-Kuraev-Lipatov dynamics in production of two jets separated by a rapidity gap

C. Baldenegro[1], D. Colferai[2], F. Deganutti[1], P. Gonzalez[3], M. Kampshoff[3], M. Klasen[3], C. Royon[1], J. Salomon[3], and Z. Warner[1]

[1]University of Kansas, US
[2]U. di Firenze, Italy
[3]U. of Muenster, Germany

In the high-energy limit of quantum chromodynamics (QCD), large logarithms of energy compensate for the smallness of the strong coupling constant, α_s. Fixed-order perturbative QCD (pQCD) breaks down in this limit, since an all-orders resummation is necessary in order to obtain sensible results. The Balitsky-Fadin-Kuraev-Lipatov (BFKL) [1,2,3] evolution equation can be used to account for the resummation of these large logarithms of energy in the high-energy limit of QCD. For the Snowmass process, we propose to further investigate two jet production where the jets are separated by a large rapidity interval void of particle activity, known as a rapidity gap. The latter process is known as Mueller-Tang jets or jet-gap-jet [4]. The rapidity gap signature is indicative of an underlying color-singlet exchange mechanism. In the high-energy limit of QCD, it is expected that BFKL pomeron exchange might be the dominating strong interaction mechanism responsible for generating the rapidity gap. Contributions based on the Dokshitzer-Gribov-Lipatov-Altarelli-Parisi (DGLAP)[5,6,7] approach are expected to be strongly suppressed in dijet events with a central rapidity gap by virtue of a Sudakov form factor. Thus, the jet-gap-jet process may allow us to device observables sensitive to BFKL dynamics, complementary to other standard probes of this regime of QCD interactions.

There has been progress in recent years from the experimental and theoretical point of view. The CMS Collaboration has presented results on jet-gap-jet production at 7 TeV [8] and more recently at 13 TeV [9]. Present calculations that account for the resummation effects at next-to-leading logarithm (NLL) accuracy with leading order (LO) impact factors are not able to describe all features of recent data [9]. Recent progress has been made in the completion of predictions at next-to-LO (NLO) in α_s [10] by including the NLO impact factor in the jet-gap-jet cross section calculation [11,12]. For the Snowmass 2021 process, we plan to perform a phenomenology analysis with updated calculations (NLL+LO and NLL+NLO) in light of recent data. We will explore possible observables that could be used in future measurements that may help better disentangle BFKL evolution effects from DGLAP dynamics, beyond the ones previously used by the Tevatron and CMS experiments. In particular, we aim to explore the role of parton distribution functions, multiparton interactions, parton shower evolution, and hadronization in the description of this process, as well as proposing ways to suppress their model-dependent effects for a better interpretation of data.

References

[1] E. A. Kuraev, L. N. Lipatov, and V. S. Fadin, "The Pomeranchuk singularity in nonabelian gauge theories", Sov. Phys. JETP 45 (1977) 199.

[2] I. I. Balitsky and L. N. Lipatov, "The Pomeranchuk singularity in quantum chromodynamics", Sov. J. Nucl. Phys. 28 (1978) 822.

[3] L. N. Lipatov, "The bare pomeron in quantum chromodynamics", Sov. Phys. JETP 63 (1986) 904.

[4] A. Mueller and W.-K. Tang, "High energy parton-parton elastic scattering in QCD", Phys. Lett. B 284 (1992) 123, doi:10.1016/0370-2693(92)91936-4.

[5] Y. L. Dokshitzer, "Calculation of the structure functions for deep inelastic scattering and + e e annihilation by perturbation theory in quantum chromodynamics", Sov. Phys. JETP 46 (1977) 641.

[6] G. Altarelli and G. Parisi, "Asymptotic freedom in parton language", Nucl. Phys. B 126 (1977) 298, doi:10.1016/0550-3213(77)90384-4.

[7] V. N. Gribov and L. N. Lipatov, "Deep inelastic ep scattering in perturbation theory", Sov. J. Nucl. Phys. 15 (1972) 438.

[8] CMS Collaboration, "Study of dijet events with a large rapidity gap between the two leading jets in pp collisions at sqrt(s) = 7 TeV", Eur. Phys. J. C 78 (2018) 242, doi:10.1140/epjc/s10052-018-5691-6, arXiv:1710.02586.

[9] CMS, TOTEM Collaborations. "Study of hard color singlet exchange in dijet events with proton-proton collisions at sqrt(s) = 13 TeV", CMS-PAS-

SMP-19-006.

[10] Federico Deganutti, David Gordo Gomez, Timothy Raben, Christophe Royon, "Pomeron Physics at the LHC" 10.1051/epjconf/201817206006, arXiv:1711.07514.

[11] M. Hentschinski, J. D. Madrigal Martınez, B. Murdaca, and A. Sabio Vera, "The next-to-leading order vertex for a forward jet plus a rapidity gap at high energies", Phys. Lett. B 735 (2014) 168, doi:10.1016/j.physletb.2014.06.022, arXiv:1404.2937.

[12] M. Hentschinski, J. D. Madrigal Martınez, B. Murdaca, and A. Sabio Vera, "The gluon-induced Mueller-Tang jet impact factor at next-to-leading order", Nuclear Physics B 889 (2014) 549, doi:10.1016/j.nuclphysb.2014.10.026, arXiv:1409.6704.