Geometric Scaling and Froissart Bound in the Color Glass Condensate

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We explain how two important physics at high energy scattering, "*geometric scaling*" and "*unitarity bound*", can be understood from the viewpoint of "*gluon saturation.*"

"*Geometric scaling*" is a new experimental fact in small x physics meaning that the DIS cross section which is originally a function of two independent variables (virtuality of photon Q^2, and the Bjorken x) becomes just a function of only one variable $Q^2R(x)$ at small x. This can be naturally understood from the Color Glass Condensate, a matter of saturated gluons, because its dynamics is predominantly described by the "saturation scale $Q_s(x)$" with energy dependence, which allows us to identify $R(x)$ with $1/Q_s(x)$. This interpretation works well below the saturation scale. On the other hand, based on the analysis of the linear evolution equations in QCD (the BFKL equation), we found that geometric scaling holds in a large kinematical window, which extends above the saturation scale up to momenta Q of order 10 GeV. Indeed, for scale $Q_s < Q < Q_s^2/\Lambda_{\rm QCD}$, the solution to the BFKL equation shows approximate scaling.

"*Unitarity bound*" or Froissart bound means the upper bound of total cross section in the hadron-hadron scattering. It is known that the usual linear evolution equations such as the BFKL equation predict too rapid growth of gluon density and eventually violate the unitarity bound. Here, we present a simple picture of how the total hadronic cross section saturates the Froissart bound in the Color Glass Condensate. We argue that the saturation momentum $Q_s(x,b)$ as a function of x and impact paremeter b factorizes into a product of $Q_s(x)F(b)$ where the function $F(b)$ is determined only by boundary conditions at larger x. Using an intuitively obvious form for $F(b)$, we show the cross section for all hadrons rise as $\ln^2(E)$ when the coupling constant is independent of the saturation momentum and $\ln(E)$ when it is allowed to run with the saturation momentum. The coefficient of the logarithm is universal and independent of hadron species.

References

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[2] E. Iancu, K. Itakura and L. McLerran, *Froissart Bound from Gluon Saturation*, in preparation