Two-Gluon Correlations in Heavy-Light Ion Collisions

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I) Abstract

We derive the cross-section for two-gluon production in heavy-light ion collisions in the saturation/Color Glass Condensate framework. This is the first-ever two-gluon production calculation including saturation effects to all orders in one of the nuclei (heavy ion) along with a single saturation correction in the projectile (light ion). The calculation of the correlation function predicted (qualitatively) two identical ridge-like correlations, near- and away-side. This prediction was later supported by experiment findings. Concentrating on the energy and geometry dependence of the correlation functions we find that the correlation function is nearly center-of-mass energy independent. The geometry dependence of the correlation function leads to an enhancement of near- and away-side correlations for the tip-on-tip U+U collisions when compared with side-on-side U+U collisions, an exactly opposite behavior from the correlations generated by the elliptic flow of the quark-gluon plasma.

II) The Ridge

The correlations of interest are two-particle, ridge like, correlations which are long-range in rapidity and centered in azimuthal angle. Originally observed in A+A collisions and it has since been observed in p+p and p-p collisions. The data above is from the STAR collaboration for Au+Au collisions. [1]

Due to causality argument, long-range rapidity correlations must originate from early-time dynamics.

III) Two-Gluon Correlations

Since gluons dominate the early-time dynamics we model the two-particle correlations by calculating the two-gluon correlations.

IV) Saturation Physics Calculation

Due to multiple scattering in high energy ion collisions, the gluon density does not increase indefinitely, it gets cut-off at the saturation scale, Q_s. This is known as saturation physics and is used to describe the early-time gluon dynamics.

A quark or a gluon propagating through a nucleus at high energy can be thought of as traveling through a shockwave, modeled as a Wilson line.

We look at heavy-light ion collisions. Two gluons are emitted from two different nucleons inside the projectile (the light ion). These gluons then interact with the target (the heavy ion).

V) Energy Dependence

We use the BK evolution equations to evolve the center of mass energy of the two gluons, increasing the rapidity gap between the projectile and the emitted gluons. The BK equation cannot be solved exactly but there exists known analytic approximations. We are using the approximation for the k_1, k_2 ∝ Q_s(y) limit.

We relate the BK solution to our result using Gaussian truncation. Process has numerical support. [4]

The resulting correlation function is nearly energy independent.

VI) U+U Collisions

To see ellipticity's effect on the correlation we compare two different collisional geometries of U+U, head- and side-on collisions. The Uranium is modeled as a prolate ellipsoid, the collision at zero impact parameter and at leading order in saturation scale (in the large k_lim limit). We insert the below nuclear profile functions in the lowest-order correlation function result.

Results in an enhancement for head-on collisions as compared to side-on collisions. Opposite of elliptic flow, it can be used to differentiate the two effects.

Bibliography

3) ALICE Collaboration Collaboration, B. Abelev et al., Long-range angular correlations on the near and away side in p-Pb collisions at sqrt(sNN) = 5.02 TeV, [arXiv:1212.2001].

Based on the works: