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Executive Summary

Relevance of the Thermal Effects in Collisions of Small Systems

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The importance of this observable as a gauge of partonic interactions in the perturbative quantum chromodynamics (pQCD) domain is first highlighted. Relevant data about the collision system's initial state dynamics can be gleaned from the particle spectra. On the other hand, the hydrodynamic expansion of the hot environment produced by heavy ion collisions has been exploited as a probe of the collective behaviour revealed by the p_T spectrum. It is claimed that the p_T spectrum can be explained by applying a temporal separation to the Boltzmann transport equation's Relaxation Time Approximation (RTA). The hadrons created in the initial state of hard collision and those formed in the equilibrium scenario are separated in time. The main goal of the study was to investigate the nuclear modification factors for pion production. Small system collisions measured by the PHENIX experiment at RHIC (Relativistic Heavy Ion Collider).

The XA cross-section can be written as the convolution of the Parton distribution functions (PDFs) of the tiny projectile (designated here as X) and the nucleus A with the hard parton level cross-section in the collinear factorization formalism of pQCD. The alteration of the Parton distribution within a nucleus as compared to that in a free nucleon is how the nuclear modification factor is stated in this context. The shadowing and anti-shadowing effects in nuclear structure functions investigated by deep-inelastic-scattering (DIS) events are caused by these alterations.

The *He* nucleus is predicted to have a higher peak and a bigger shadowing effect in the early dispersion. It was confirmed, nonetheless, that the thermal contribution at low p_T helps to mitigate these consequences. Similar behaviour is seen in heavy-ion collisions, where the generated particles balance out the expected suppression brought on by the nuclear UGD's strong nuclear shadowing.

This study examined the relevance of temperature effects in collisions of tiny systems using an analysis of the neutral pion transverse momentum spectra obtained at the RHIC (Relativistic Heavy Ion Collider). The relaxation time estimate has considered the Boltzmann equation. It was demonstrated that even at high transverse momentum, p_T, the hard part contribution associated with an initial production computed within the k_T-factorization formalism in pQCD (perturbative quantum chromodynamics) exhibits a distinct behaviour from the one experimentally observed. The divergence can be explained in terms of the increase or suppression of particles created during the thermal system's overall expansion. It has been established that the projectile species does not affect the nuclear modification factor, R_{xA}, at p_T 10 GeV.

Journal Reference

Moriggi, L.; Machado, M., 2022. Nuclear Modification Factor in Small System Collisions within Perturbative QCD Including Thermal Effects. Physics 2022, 4, 787–799.

KEYWORDS

kT-factorization approach; parton saturation phenomenon; geometric scaling in hadron–hadron collisions; high-energy collisions; multiparticle production; transverse momentum distribution