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A unified picture for dilute-dense dynamics in nuclear medium

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We elucidate the relationship between Color Glass Condensate (CGC) and Higher-twist (HT) formalisms at the level of physical observables by studying the direct photon production in proton-nucleus collisions. The CGC effective theory and the HT factorization theorem are two established formalisms that describe multiple scatterings of quarks and gluons in nuclear media within Quantum Chromodynamics (QCD). These formalisms have distinct domains of validity in kinematic regions. Going beyond the shock wave approximation and considering the Landau-Pomeranchuk-Migdal effect, which arises from the interference of initial- and final-state scatterings, we show for the first time that CGC and HT formalisms can be unified to describe the same physics in the transition region where they overlap. This unified picture provides a framework for understanding the QCD dynamics in the transition from dilute to dense nuclear matter, paving the way for mapping out the QCD evolution phase diagram of nuclear medium from dilute to dense region. This study highlights the importance of sub-eikonal phases in accurately describing multiple scatterings in nuclear media and sheds new light on the interplay between HT and CGC formalisms.

Category

Theory

Collaboration (if applicable)

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