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Exploring Gluon Dynamics in the Small-X Regime of QCD

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Understanding Quantum Chromodynamics (QCD) in the small Bjorken-x regime is essential for probing the high-density gluon environment relevant to future high-energy collider experiments. While perturbative QCD techniques like DGLAP evolution provide a successful description at moderate x, they be- come inadequate as $x \longrightarrow 0$, where gluon densities rise and nonlinear effects, such as saturation, emerge. This talk presents a study aimed at unifying the Parton Model and the QCD Dipole Framework—specifically connecting DGLAP and BK evolution equations—through a machine learning approach. By computing key observables such as structure functions and cross-sections, we seek to refine parton distribution functions (PDFs) and offer improved predictions for deep in- elastic scattering processes. This unified perspective paves the way for a deeper understanding of QCD in the high-density regime and supports experimental efforts at the upcoming Electron-Ion Collider.

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