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Analytical solution of the nonlinear QCD evolution equations and its applications

In high-energy scattering processes, the partonic density exhibits a crucial phenomenon, primarily dominated by gluonic density at the small-x region. The partonic density increases rapidly with the decrease in Bjorken-x owing to gluon splitting, while the overlapping gluons begin to recombine and become prevalent at high-density. This results in a balance between splitting and recombination, leading to a new state of gluon saturation. The saturation phenomenon is extensively studied through nonlinear evolution equations such as the Balitsky-Kovchegov (BK) equation and the Gribov-Levin-Ryskin-Mueller-Qiu (GLR-MQ) equation.

To provide a more intuitive physical picture and analyze the saturation properties of these nonlinear evolution equations, we employ the homogeneous balance method for the first time to derive analytical solutions for both the BK equation and GLR-MQ equation. Our findings reveal that geometric scaling is an inherent characteristic of our analytical solution, with gluon distribution functions derived from this solution successfully reproducing MSTW2008LO data. Furthermore, predictions regarding J/ψ mesons demonstrate good agreement with experimental data. These results indicate that our analytical solution obtained via the homogeneous balance method effectively describes gluon behavior in the small-x regime.

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