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Analytical solution of the nonlinear QCD evolution equations using the homogeneous balance method

The QCD evolution equations serve as both a theoretical cornerstone and an experimental foundation in high-energy nuclear physics, which are powerful for studying quantum chromodynamics, understanding hadron structure and interaction between hadrons. QCD predicts that the gluon density inside hadrons will increase rapidly in high-energy collisions, and eventually form a high gluon density saturation state. This saturation effects can be described by the nonlinear BK and GLR-MQ equations. In order to provide a more intuitive physical picture and analyze the saturation property of these nonlinear evolution equations, we employ the homogeneous balance method for the first time to obtain the analytical solutions of the BK equation and the GLR-MQ equation. It is found that the analytical solutions can naturally obtain the geometric scaling properties observed in high-energy physics experiments. By fitting the experimental data, we determine the free parameters in the analytical solution and obtain the exact solution of the evolution equation, which is in good agreement with the numerical solution. We also predict the J/ψ meson production by using the exact solution. The numerical results show that the exact solution can describe the J/ψ meson production well.

References：

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