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Equilibration in finite gluon systems

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The equilibration of a finite Bose system is modelled using a gradient expansion of the collision integral in the bosonic Boltzmann equation that leads to a nonlinear transport equation. Employing a method that had been proposed earlier for the analytical solution of the equilibration problem in a finite fermion system [1], the basic equation for bosons and in particular, gluons, is solved in closed form for constant transport coefficients through a nonlinear transformation.

With initial conditions that are appropriate for the gluon system in a relativistic heavy-ion collision such as Au+Au or Pb+Pb at energies reached at RHIC or LHC, the exact solution is derived. It agrees well with the numerical solution of the nonlinear equation. The analytical expression for the local equilibration time in the thermal tail is compared to the corresponding case for fermions. The method is also applicable to the (nonrelativistic) equilibration of a cold quantum gas.

Due to the nonlinearity of the basic equation, the sharp edges of the initial gluon distribution at Q_s ≈ 1 GeV are continously smeared out and local equilibrium of the gluon distribution with a thermal tail in the ultraviolett region is rapidly attained [2]. Although gluon condensate formation at p=0 is in principle possible, due to inelastic processes and the nonconservation of particle number in relativistic collisions this appears unlikely to occur in heavy-ion collisions.

The thermal equilibration time for gluons turns out to be nine times shorter than the equilibration time for fermions (quarks) as a consequence of the statistical properties of bosons versus fermions [2]. This result can be viewed as one of the main reasons for the very short local equilibration time in relativistic heavy-ion collisions that are dominated by gluons in their initial stage.

[1] G. Wolschin, Phys. Rev. Lett. 48, 1004 (1982).
[2] G. Wolschin, submitted to Physica A (2017); arXiv:1712.02659.

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