Strong-coupling diffusion in relativistic systems

Georg Wolschin [a]

[a] *Heidelberg University*

Presented by: G. Wolschin

Abstract

Phase-transition scenarios to a quark-gluon phase are based on the assumption that at least a substantial part of the system thermalizes [1]. In this work, the equilibration in the system of participant baryons is investigated analytically in a relativistic diffusion model (RDM) from SIS via AGS to SPS energies [2]. A prediction for RHIC proton rapidity distributions demonstrates the nonequilibrium behaviour of the baryonic system at higher energies.

A very general description of relaxation processes in nonequilibrium systems is provided by the Fokker-Planck equation (FPE) [3]. If applied to Lorentz-invariant observables such as the rapidity, the approach is suitable at relativistic energies [4]. In particular, it has been shown that proton rapidity distributions can be represented on the basis of a linear Fokker-Planck equation as outlined in the RDM [2].

In a weak-coupling situation (where the duration of a single interaction is smaller than the time between two subsequent collisions), the transport coefficients are related to each other through the temperature T_p of the thermal equilibrium distribution. I have derived [2] the corresponding weak-coupling dissipation-fluctuation theorem (Einstein relation), and compared it to experimental proton rapidity spectra from SIS to SPS energies. The relations are fulfilled at low SIS-energies [5], whereas progressively larger deviations rising to an order of magnitude are found at AGS- and SPS-energies.

This effect is investigated [6] as a consequence of the strong-coupling character of the system which is clearly evident at SPS-energies and beyond. The rapidity diffusion coefficient becomes time-dependent, and by far exceeds the weak-coupling value at short times. The corresponding FPE is solved analytically. With empirical values for the strong-coupling rapidity diffusion coefficient, predictions for the 40 A GeV/c SPS, and 2*100 A GeV/c RHIC results are made. At RHIC energies, the proton rapidity distribution shows two clearly separated peaks indicating that the system of participant baryons - no matter whether it passes through a deconfined phase or not - does not reach statistical equilibrium. Hence, the successful appli-

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cation of thermodynamical concepts to hadron production does not imply that the baryonic system has actually reached statistical equilibrium.

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