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Fluid dynamics far-from-equilibrium: a concrete example

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The applicability of fluid-dynamical models in the extreme conditions produced in heavy ion collisions has not yet been properly understood from a theoretical point of view. This happens mostly because the derivation of hydrodynamics from microscopic theory often relies on the assumption that the system is sufficiently close to local equilibrium – something difficult to justify in the rapidly expanding systems created in heavy ion collisions.

In this contribution we propose a more general derivation of relativistic fluid dynamics from kinetic theory, in which the fluid is assumed to be close to an isotropic non-equilibrium state instead of an equilibrium one. We demonstrate that, for a wide variety of non-equilibrium states, one obtains a hydrodynamic theory described by equations of motion that are identical to those commonly solved in heavy ion collisions. The only difference appears in the form of the transport coefficients that enter the equations of motion. Simulations of the relativistic Boltzmann equation equation in 0+1D Bjorken flow in the ultrarelativistic limit are performed to demonstrate this effect, showing that the time evolution of the energy-momentum tensor appears to be fluid-dynamical even when the momentum distribution of the underlying degrees of freedom differs significantly from an equilibrium distribution.

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