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Relating the Lyapunov exponents to transport coefficients in kinetic theory

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In this work we discuss the phenomenological applications of non-equilibrium hydrodynamical attractors to transport phenomena in fluid dynamics. We study the late-time behaviour of a relativistic fluid undergoing Bjorken flow whose microscopic description is given in terms of the Boltzmann equation with a time-dependent relaxation time. The mathematical problem of solving the Boltzmann equation is recast into an infinite set of nonlinear ordinary differential equations for the moments of the one-particle distribution function. Viewed this as a dynamical system of coupled ODEs, we can then determine with a suitable truncation, the non-equilibrium attractor solution of the Boltzmann equation from a small set of hydrodynamic and non-hydrodynamic moments of the one-particle distribution function. The asymptotic expansion of the attractor allows us to extract numerically the values of the Lyapunov exponents and at the same time, the values of different transport coefficients like the shear viscosity. As a result we are able to establish an empirical relation between the maximal Lyapunov exponent and the shear viscosity in relativistic kinetic theory. We comment on how to generalize our results and the possible implications of our findings in hydrodynamical simulations of relativistic heavy ion collisions.

Content type

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