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Connecting far-from-equilibrium hydrodynamics to resummed transport coefficients and attractor solutions

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We show how far-from-equilibrium hydrodynamics may be systematically defined, for arbitrary flow profiles, in terms of a generalized tensorial expansion with transport coefficients that contain an all order resummation in gradients. In this formulation, the transport coefficients of far-from-equilibrium fluid dynamics depend not only on the microscopic properties of the system but also on the nonlinear properties of the underlying state of the fluid itself. In contrast to previous works, no additional assumptions about the symmetries of the flow are necessary. An example of this proposal is constructed using Israel-Stewart theory and, in this case, the resummed transport coefficients decrease with increasing Knudsen number according to formulas that can be readily investigated in current numerical simulations of the quark-gluon plasma. We check numerically the existence of attractor solutions in simulations of AA and pA collisions. This is particularly important to understand the apparent hydrodynamic behavior observed in small systems where gradients are extremely large and resummation techniques should be employed.

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