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Applicability of higher-order hydrodynamics in heavy-ion collisions

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We study the boost-invariant non-conformal Boltzmann equation in the relaxation-time approximation using special moments of the distribution function and investigate how hydrodynamical behavior emerges as the plasma transits from the far-off-equilibrium free-streaming regime to the hydrodynamic regime. The infinite hierarchy of moments can be truncated by keeping only the three lowest moments that correspond to the three independent components of the energy-momentum tensor. By comparing the moment equations with the Israel-Stewart hydrodynamic equations, we demonstrate that the latter are able to capture the early-time, collisionless dynamics, albeit approximately, due to their relaxation-type structure [1]. We also derive second-order non-conformal hydrodynamics from the three-moment truncation and find that there are ambiguities in the definition of some second-order transport coefficients. In order to understand the nature of these ambiguities, we derive the full second-order non-conformal hydrodynamics by employing Chapman-Enskog expansion and also from a novel entropy approach and show that such ambiguities are inherent when defining some of the second-order transport coefficients [2]. We show that these ambiguities affect the ability of the Israel-Stewart hydrodynamics to reproduce the results of kinetic theory. The implications of these results in the context of heavy-ion collisions will be discussed.

[1] From moments of the distribution function to hydrodynamics: The nonconformal case, S. Jaiswal, J. P. Blaizot, R. S. Bhalerao, Z. Chen, A. Jaiswal and L. Yan, Phys. Rev. C 106, 044912 (2022)

[2] Shear-bulk coupling in second-order viscous hydrodynamics, S. Jaiswal, J. P. Blaizot (in preparation)

Category

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