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Divergence of the gradient and slow-roll expansions in Bjorken and Gubser flow

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Relativistic hydrodynamics has played a key role in our understanding of the novel properties of quark-gluon plasma. However, the validity of hydrodynamical models in describing the extreme conditions produced in heavy ion collisions has still not been properly justified theoretically. Even more, the gradient expansion, commonly used to derive hydrodynamics from microscopic theory, has been recently shown to diverge for conformal fluids or relativistic gases undergoing Bjorken flow [1,2], putting under question the definition of hydrodynamics itself. Alternative derivation of the hydrodynamic series have been proposed recently, such as the slow-roll expansion [1], and can be promising candidates to define hydrodynamics.

In this contribution, we present general analytical and semi-analytical solutions of the hydrodynamic attractor of Israel-Stewart theory [2] and kinetic theory for Bjorken and Gubser expanding fluids. We show that the gradient expansion diverges in both cases. For Israel-Stewart theory, we show for the first time that even the slow-roll expansion, a commonly used approach to characterize the attractor, diverges. Finally, we construct the slow-roll expansion for a general flow scenario and find the effective shear viscosity [3] and relaxation time that are able to describe a more general hydrodynamic regime.

[1] M. P. Heller and M. Spalinski, "Hydrodynamics Beyond the Gradient Expansion: Resurgence and Resummation," Phys. Rev. Lett. 115, no. 7, 072501 (2015).
[2] G. S. Denicol and J. Noronha, "Analytical attractor and the divergence of the slow-roll expansion in relativistic hydrodynamics," arXiv:1711.01657 [nucl-th].
[3] P. Romatschke, "Relativistic Hydrodynamic Attractors with Broken Symmetries: Non-Conformal and Non-Homogeneous," arXiv:1710.03234 [hep-th].

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