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Projection method and new formulation of leading-order anisotropic hydrodynamics

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Successful applications of relativistic viscous hydrodynamics in the description of heavy-ion collisions at RHIC and the LHC triggered large interest in the development of the hydrodynamic framework. An example of the new approach to relativistic dissipative hydrodynamics is anisotropic hydrodynamics — the framework where effects connected with the expected high pressure anisotropy of the produced matter are included in the leading order of the hydrodynamic expansion.

Very recently, also the second order anisotropic hydrodynamics has been formulated in [1]. The new approach introduced in [1] allows for description of arbitrary transverse expansion of matter in the way which becomes consistent with more traditional approaches to dissipative hydrodynamics in the small anisotropy limit. This formalism uses, however, the Romatschke-Strickland form [2] of the distribution function in the leading order, which implies that the two components of pressure in the transverse plane may be different only if the second-order corrections are taken into account.

In this work we present a new methodology for including three substantially different pressure components already in the leading order of hydrodynamic expansion. Our approach is based on the projection method introduced in [3], which has turned out to be a convenient tool to replace complicated tensor equations of relativistic hydrodynamics by a small set of scalar equations.

We take into account the radial expansion of the produced matter (in addition to the longitudinal Bjorken flow) but our considerations are confined to the case with cylindrical symmetry. We generalize the Romatschke-Strickland form to the case where all three pressure components may be different. Compared to earlier works on anisotropic hydrodynamics in the leading order, where the zeroth and first moments of the Boltzmann equation have been studied, an important novel feature of our present work is the analysis of the second moment of the Boltzmann equation. We argue that a successful agreement with the Israel-Stewart theory in the limit of small anisotropies may be achieved if we take into account two equations constructed from the second moment of the Boltzmann equation rather than taking one equation from the zeroth moment and another equation from the second moment [4].

[1] D. Bazow, U. Heinz, and M. Strickland, arXiv:1311.6720.

[2] P.Romatschke and M.Strickland, Phys. Rev. D68 (2003) 036004.

[3] W. Florkowski and R. Ryblewski, Phys. Rev. C85 (2012) 044902.

[4] L. Tinti, W. Florkowski, arXiv:1312.6614.

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