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Investigating applicability of fluid dynamics in heavy ion collisions

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We investigate the applicability of fluid dynamics (FD) in relativistic heavy-ion collisions by comparing its solutions to those of the relativistic Boltzmann equation (BE) [1]. The latter can be solved numerically [2] and its FD limit is well known [3]. We consider various (2+1)-dimensional boost-invariant scenarios, with realistic initial transverse profiles of energy and particle density. By varying the system size and the cross section we then identify regions where FD is a good approximation to the BE.

We observe that the space-time evolution of energy density and fluid velocity is well described by FD for all considered values of the cross section. However, the FD shear-stress tensor starts to deviate from its BE counterpart when the Knudsen number Kn, defined as a mean free path times the local expansion rate, exceeds a value of one.

We furthermore study the elliptic flow generated for Glauber-type initial conditions. We consider various decoupling conditions in FD and identify the Kn regions where the elliptic flow is generated. Decoupling at a constant $\mathrm{Kn} \sim 2 - 3$ gives a good agreement with the solutions of the BE when the cross section is sufficiently large, i.e., when most of the elliptic flow is generated during the evolution where $\mathrm{Kn} < 1$. With decreasing cross section most of the flow signal is generated in regions where $\mathrm{Kn} > 1$. In this case, the FD elliptic flow starts to deviate from that generated by the BE.

[1] K. Gallmeister, H. Niemi, C. Greiner, D. H. Rischke, in preparation

[2] Z. Xu and C. Greiner, Phys. Rev. C71, 064901 (2005)

[3] G. Denicol, H. Niemi, E. Molnar and D. H. Rischke, Phys. Rev. D85, 114047 (2012)

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