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Turbulent fluctuations around Bjorken flow

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For large Reynolds number (which is inverse to viscosity), fluids are known to develop turbulence. Therefore, the phenomenological evidence for a small viscosity suggests that the hydrodynamical description of heavy ion collisions may have a turbulent regime. Assuming that averaged velocities are described by Bjorkens model, we investigate local fluctuations around it. These perturbations are governed by non-linear equations and we characterize classes of qualitatively different evolution in terms of Reynolds numbers. Perturbations at different rapidities are found to decouple quickly, and the local evolution becomes effectively two-dimensional. The resulting Navier-Stokes equation of non-relativistic form (obtained after suitable coordinate transformations) can be discussed within the theory of Kolmogorov and Kraichnan. In particular, unlike three-dimensional turbulent flow, two-dimensional viscous fluid dynamics can show the interesting phenomenon of inverse cascading of energy into large scale structures. We speculate on possible phenomenological implications of these findings.

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