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Stationary fluctuation theorem in high-energy nuclear collisions

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The QGP created at RHIC and LHC behaves like a perfect fluid, which suggests it reaches thermal equilibrium state. Stability of thermal equilibrium state is a consequence of an interplay between thermal fluctuation and dissipation. On the other hand, only dissipation has been taken into account in event-by-event hydrodynamic simulations for the past years. In addition to dissipation, thermal fluctuations during hydrodynamic evolution (a.k.a., hydrodynamic fluctuation) must be taken into account to consistently describe the dynamics of the QGP. To study this, causal fluctuating hydrodynamics was formulated [1] and implemented in numerical hydrodynamic simulations recently [2]

In this study, we apply this framework to the (0+1)-dimensional Bjorken expansion and show that, under some limited conditions, the dynamics of the QGP satisfies "stationary fluctuation theorem" [3] which was established in non-equilibrium statistical physics. Through this theorem, we focus on the entropy fluctuation and claim that the thermal fluctuation becomes more important in the smaller systems such as p-A and peripheral A-A collisions. We further investigate the effects of finite relaxation time in causal hydrodynamics and find it significantly affects the final entropy distribution. This suggests we have an opportunity to extract some information about relaxation time from final observables on multiplicity.

[1] K. Murase and T. Hirano, arXiv:1304.3243.

[2] K. Murase, Ph.D thesis, submitted to the Univ. of Tokyo (2015).

[3] D.J. Evans and D.J. Searles, Phys. Rev. E 52, 5839 (1995).

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