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Fluctuating Hydrodynamics under Uniform Gradients: Historical Context and New Insights

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概　要

Standard hydrodynamics serves as a successful macroscopic description of fluid motion, ranging from engineering applications to turbulent flows. However, this framework is inherently deterministic and neglects the fluctuations that inevitably arise due to their underlying atomic structure. In particular, these fluctuations govern fluid phenomena at the mesoscopic scale between the microscopic and macroscopic scales. Fluctuating hydrodynamics extends the classical description by incorporating thermal fluctuations, leading to a more accurate description of such mesoscopic transport phenomena.
Recently, we analyzed the strong non-equilibrium fluctuations exhibited by fluids subjected to uniform gradients, such as single-component fluids under a shear flow or a temperature gradient and multi-component fluids under a concentration gradient [1-3]. These phenomena are one of the most well-established examples requiring a fluctuating hydrodynamic description, having been precisely observed in microgravity experiments. We performed direct numerical simulations (DNS) of the fluctuating hydrodynamic equations, and investigated the properties of energy dissipation and fluid behavior in the inviscid limit. In this seminar, I will present these findings alongside a historical review of the development and analysis of fluctuating hydrodynamics.

[1] HN, and K. Yokota, Phys. Rev. E **111**, L063401 (2025)
[2] HN, Y. Minami, and K. Saito, arXiv:2502.15241(2025)
[3] HN, and Y. Minami, arXiv:2511.17851 (2025)

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