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Langevin simulation of gas flows

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A stochastic algorithm based on the Langevin equation has been recently proposed to simulate rarefied gas flows [1, 2]. Compared with the direct simulation Monte Carlo (DSMC) method [3], the Langevin method is more efficient in simulating small Knudsen number flows [4]. While it is well-known that the cell sizes and time steps should be smaller than the mean free path and the mean collision time, respectively, in DSMC simulations, the Langevin equation uses a drift term and a diffusion term to describe molecule movements, so no direct molecular collisions have to be modeled. This enables the Langevin simulation to proceed with a much larger time step than that in the DSMC method. A critical issue in Langevin simulation is how to reproduce the transport properties as that described by kinetic theory. In this paper the analytical transport coefficients, including diffusion, viscosity and heat conduction coefficients are obtained by using Green–Kubo formulae. Couette flow, thermal Couette flow and Rayleigh–Bénard flow are then simulated with the analytical transport coefficients. The results obtained by Langevin simulation compare well with the corresponding DSMC results. Our study shows that Langevin simulation is a promising tool to investigate small Knudsen number flows.

References

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