Steady-State and Transient Coupling of Lattice Boltzmann and Navier-Stokes Solvers

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Abstract

Both Lattice Boltzmann (LB) and (incompressible) Navier-Stokes (NS) solvers come with advantages and disadvantages. LB methods provide accurate prediction of fluid flow over a wide range of temporal and spatial scales, including the regimes of fluctuating hydrodynamics [1] and the finite Knudsen regime [2]. From the algorithmic perspective, they are simple and local in their computations. This allows for highly efficient, massively parallel simulations [3] as well as (block-adaptive) GPU variants [4]. Incompressible NS solvers typically come with lower memory consumption requirements. They often allow the use of coarser grids and rigorous higher-order discretizations such as discontinuous Galerkin approaches [5,6] which are rather uncommon in the LB framework. Hence, LB or NS, or a combination of both to exploit their features to highest extent may be favorable for a particular flow problem. In this contribution, I present methods to spatially couple LB and NS solvers for both steady-state and transient simulations. I discuss the mapping of unknowns at the solver interfaces, show validation results from various numerical experiments (different channel scenarios, Taylor-Green, and Couette flow), and point out parallelization aspects in the coupled simulation.

References

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