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Coupling of Two Discretization Schemes for the Lattice Boltzmann Equation

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Abstract : Despite the efficiency and low dissipation of the stream-collide formulation of the Lattice Boltzmann (LB) algorithm, which is nowadays implemented in many commercial LBM solvers, there are certain situations, e.g. mesh transition, in which a classical finite-volume or finite-difference formulation of the LB algorithm still bear advantages. In this paper, we present an algorithm that combines the node-based streaming of the distribution functions with a second-order finite volume discretization of the advection term of the BGK-LB equation on a uniform D2Q9 lattice. It is shown that such a coupling is possible for a multi-domain approach as long as the overlap, or buffer zone, between two domains, is achieved on at least $2\Delta x$. This also implies that a direct coupling (without buffer zone) of a stream-collide and finite-volume LB algorithm on a single grid is not stable. The critical parameter in the coupling is the CFL number equal to 1 that is imposed by the stream-collide algorithm. Nevertheless, an explicit filtering step on the finite-volume domain can stabilize the solution. In a further investigation, we demonstrate how such a coupling can be used for mesh transition, resulting in an intrinsic conservation of mass over the interface.

Keywords : algorithm coupling, finite volume formulation, grid refinement, Lattice Boltzmann method
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