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FINITE VOLUME LATTICE BOLTZMANN COMPRESSIBLE APPROACH FOR BOUNDARY CONDITIONS

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Lattice Boltzmann Methods (LBM) have recently emerged as an alternative powerful tool for the simulation of fluid dynamics [1] both in the academic and industrial spheres. These methods have shown a growing interest [2, 3, 4] due to its attractive computational cost as well as its capacities for massively parallel computing and the ease to deal with complex geometries using multi-level Cartesian grids. It differs from classical numerical methods due to its mesoscopic approach inherited from the fluid kinetic description. LBM is a numerical representation of the Boltzmann equation in which motion of particles is balanced by collisions. Although recent efforts has been made to improve consistency of the numerical method in the context of compressible flows [5], the treatment of boundary conditions remains an open issue.

The oldest and most common method is the bounce back [3] scheme. The basic principle is that particles hitting the wall during the streaming step are reflected back in the opposite direction. This approach is particularly well suited for straight walls that are exactly halfway between solid and boundary nodes. However, it is much more difficult to apply for general configurations where the links are cut by the wall at variable distances [6]. To cope with compressible flows, another straightforward technique is to treat boundaries with a macroscopic perspective, involving interpolations on boundary points [7]. However, none of these methods are consistent with the mass conservation law or first order accurate for general configurations, lowering the method's overall accuracy.

In this work, a volumetric approach [8, 9] for hybrid LBM solvers [10, 11, 12] is proposed, preserving the global mass conservation as well as the scheme consistency. Coupled with a finite volume cartesian solver for the energy equation, populations solving mass and momentum equations are bounced back into appropriate cells through a volumetric mesoscopic consideration. A theoretical foundation for the scheme as well as a series of classic academic test cases will be presented to demonstrate the method's potential.

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