Characteristic Boundary Conditions in LBM for Fluid and Gas Dynamics

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In this work we focus on characteristic boundary conditions in a computational fluid dynamics (CFD) simulation and its application with the lattice Boltzmann method (LBM).
Frequently, the equations of interest in a CFD simulation are the Euler equations extended by a viscous term

$$\frac{\partial \mathbf{v}}{\partial t} + (\mathbf{v} \cdot \nabla)\, \mathbf{v} + \frac{1}{\rho_0} \nabla p = \nu \Delta \mathbf{v}, \qquad \nabla \cdot \mathbf{v} = 0.$$

The lattice Boltzmann method is a relatively new approach in CFD which is based on a microscopical description of the fluid by the Boltzmann equation.
For a numerical simulation, independent of the method, it might happen that not all boundaries of the numerical domain coincide with physical ones.
Unlike physical boundaries where for instance an inlet or outlet condition holds, the task for these artificial boundaries is to find a procedure which does not induce unphysical effects to the fluid. This is achieved by transparent or characteristic boundary conditions.
Here, we present different approaches of characteristic boundary conditions and derive Dirichlet conditions at these artificial boundaries. These Dirichlet conditions from a PDE formulation are then transferred to the LBM framework. Among all these different approaches, we will propose new characteristic boundary conditions for LBM, which are stated in 2D. We compare the unphysical reflections of the different approaches in a numerical simulation for a simple benchmark problem.