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"Boundary Conditions for thermal Lattice Boltzmann Methods"

Over the last few decades, lattice Boltzmann models have become an established tool to simulate fluid flow.
By streaming virtual particles (populations) along a discrete grid and colliding them on the nodes, a reduced version of the Boltzmann equation is solved. Relevant hydrodynamic moments are retained thanks to a proper discretization of the velocity space. Thus the recovery of the macroscopic Navier-Stokes equations are enabled.
The velocity stencil forms the basis for the quadrature employed and thus for the used lattice Boltzmann method (LBM). Higher order quadratures lead to stencils with multiple speed levels. These multi-speed lattices were shown to support a wider range of parameters for isothermal flow. Moreover, they enable the simulation of a coupled simulation of fluid and thermal flow (Navier-Stokes-Fourier system) based on a single set of populations. In fact, the higher moments are maintained by the higher order quadrature, and these moments correspond to respective thermal quantities.
To close the system of equation, one needs to specify populations at the boundary of the (physical) domain or the simulation domain. In this process, unknown populations (after the streaming) have to be assigned properly. Multi-speed lattices need particular care, since multiple layers of nodes have to be specified in this process, which adds complexity to the task of formulating meaningful boundary conditions for the method.
We give a brief overview of LBM, present a few boundary conditions for thermal multi-speed stencils, including some recent enhancements, and discuss the respective numerical behavior in simple test cases.