

Diffuse reflection boundary conditions for Lattice Boltzmann models

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When gas particles strike a microscopically rough wall, the particles get reflected at some random angle that is uncorrelated with their angle of incidence. This is due to particle - wall interaction, which has the effect of assigning some information belonging to the wall to the reflected particles. This process is called *diffuse reflection*. The particles that leave the wall follow the Maxwellian distribution law, parametrized by the wall velocity \mathbf{u}_w and the wall temperature T_w . We discuss the implementation of diffuse reflection boundary conditions in two Lattice Boltzmann (LB) models for which the upwind finite difference scheme is used to solve the set of evolution equations recovered after discretization of the velocity space. The first model is the standard $D2Q9$ model of Qian et al.[1] which is defined on a square lattice and is widely used to simulate the behavior of isothermal fluid systems. The second model is the thermal LB model recently developed by Watari and Tsutahara [2]. Simulation of Couette flow using the diffuse reflection boundary condition reveals the onset of a slip velocity that depends on the Knudsen number $\varepsilon = \lambda/L$, where λ is the mean free path and L is the channel width. For walls moving in opposite directions with speeds $\pm u_w$, the slip velocity is given by $u_{slip} = 2\varepsilon u_w / (1 + 2\varepsilon)$. In the case of isothermal Poiseuille flow, the slip velocity is found to depend on the lattice spacing δs and Knudsen number ε to both first and second order. The thermal LB model was used to investigate also the heat transfer between two parallel walls at rest but having different temperatures. In this case, temperature jumps are observed at the walls.

References:

- [1] Y. H. Qian, D. d'Humières and P. Lallemand, *Europhysics Letters* **17** (1992) 479
- [2] M. Watari and M. Tsutahara, *Physical Review E* **67** (2003) 036306

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