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Large Scale Lattice-Boltzmann Simulations: Computational Methods and Applications

Kandhai, B.D.

Publication date
1999

[Link to publication](#)

Citation for published version (APA):

Kandhai, B. D. (1999). *Large Scale Lattice-Boltzmann Simulations: Computational Methods and Applications*. Universiteit van Amsterdam.

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Boundary Conditions and checkerboard effects in Lattice-BGK models

Part II

3.1 Computational Methods

In the previous part of this thesis we discussed the theoretical background of LBGK in detail. In this part we address computational aspects related to LBM. We start with a benchmark study of the boundary conditions and regularly used 3D models (chapter 3). Next, we propose and verify a new technique to reduce the number of time-steps that are required to reach a steady state in LBM simulations (chapter 4). Furthermore, we discuss load balancing techniques for lattice-Boltzmann simulations that are generic for problems with a static workload (chapter 5). Finally we propose a LBM scheme on nested grids and present some preliminary numerical results (appendix A).

In principle, it is known that the truncation error of the lattice-Boltzmann method is second-order in space. However, the accuracy of the solution depends on the boundary conditions and is found to be only first-order in many cases [31, 32, 33, 34, 35]. Understanding the effect of the boundary conditions is very important since they are crucial to many fluid-dynamical simulations. We discuss the boundary conditions for two common cases, namely the bounce-back boundary condition of a solid wall and the body force—which is often used as a substitute to pressure boundaries.

Besides the boundary conditions we also report on the regularly used 3D models. The D_3Q_{15} and the D_3Q_{19} models are considered. Here D denotes the dimensionality of the problem and Q is the number of nodes per lattice point [21, 23]. We show that, in the D_3Q_{15} model, checkerboarding in the full momentum can

