Abstract Submitted
for the DFD15 Meeting of
The American Physical Society

A lattice-Boltzmann scheme of the Navier-Stokes equations on a 3D cuboid lattice HAODA MIN, CHENG PENG, LIAN-PING WANG, University of Delaware — The standard lattice-Boltzmann method (LBM) for fluid flow simulation is based on a square (in 2D) or cubic (in 3D) lattice grids. Recently, two new lattice Boltzmann schemes have been developed on a 2D rectangular grid using the MRT (multiple-relaxation-time) collision model, by adding a free parameter in the definition of moments or by extending the equilibrium moments. Here we developed a lattice Boltzmann model on 3D cuboid lattice, namely, a lattice grid with different grid lengths in different spatial directions. We designed our MRT-LBM model by matching the moment equations from the Chapman-Enskog expansion with the Navier-Stokes equations. The model guarantees correct hydrodynamics. A second-order term is added to the equilibrium moments in order to restore the isotropy of viscosity on a cuboid lattice. The form and the coefficients of the extended equilibrium moments are determined through an inverse design process. An additional benefit of the model is that the viscosity can be adjusted independent of the stress-moment relaxation parameter, thus improving the numerical stability of the model. The resulting cuboid MRT-LBM model is then validated through benchmark simulations using laminar channel flow, turbulent channel flow, and the 3D Taylor-Green vortex flow.

Lian-Ping Wang
University of Delaware

Date submitted: 28 Jul 2015 Electronic form version 1.4