Improved lattice Boltzmann flux solver and its applications to naval and ocean engineering

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Abstract

A multiphase lattice Boltzmann flux solver (MLBFS) and an immersed boundary-lattice Boltzmann flux solver (IB–LBFS) are proposed for incompressible multiphase flows and fluid-structure interaction in application of naval and ocean engineering. Solution of complex physical phenomena such as multiphase flows and fluid-structure interaction (FSI) is usually accompanied in the hydrodynamic analysis of naval and ocean engineering. Although kinds of commercial computational fluid dynamics (CFD) software are available and the technology is mature, specific optimization and effective computation methods are still essential for the problems in naval and ocean engineering.

For the simulation of incompressible multiphase flows, a multiphase lattice Boltzmann flux solver (MLBFS) is presented. The flow variables at cell centers are given from the solution of macroscopic governing differential equations (Navier–Stokes equations recovered by multiphase lattice Boltzmann (LB) model) by the finite volume method. Comparing the conventional multiphase lattice Boltzmann models which restrict their applications on uniform grids with fixed time step, the MLBFS has the capability and advantage to simulate multiphase flows on non-uniform grids.

For the simulation of FSI problems, an IB–LBFS is presented. The IB–LBFS applies the fractional-step method to split the overall solution process into the predictor step and the corrector step. The IB–LBFS effectively combines the advantages of the LBFS in solving the flow field and the flexibility of the IBM in dealing with boundary conditions. Consequently, the IB–LBFS presents a much simpler and more effective approach for simulating complex FSI problems on non-uniform grids.

Keywords: Lattice Boltzmann method, flux solver, multiphase flows, fluid-structure interaction.