Turbulent flow simulation by a multiple-relaxation-time lattice Boltzmann method with a one-equation subgrid scale model

Yasuyoshi Horibata* **and Hiroshi Takeda**†

* Faculty of Science and Engineering
Hosei University
7-2, Kajino-cho 3-chome, Koganei, Tokyo, Japan
e-mail: horibata@hosei.ac.jp

† R-flow Corporation, Ltd.
10-45, Takasago 1-chome, Soka, Saitama, Japan
e-mail: takeda@rflow.co.jp

ABSTRACT

We present large eddy simulation of turbulent flows by a lattice Boltzmann method with a one-equation subgrid scale model. We use the three-dimensional twenty-seven (D3Q27) discrete velocity model because it has the best isotropy properties and is the best choice for turbulence modelling, and the multiple-relaxation-time (MRT) scheme in order to increase the stability [1].

In lattice Boltzmann-based large eddy simulation, the Smagorinsky model has been widely used [2]. It computes the SGS eddy-viscosity from the local shear rate and a length scale.

In a one-equation subgrid scale model, however, the SGS eddy-viscosity is determined from the SGS turbulent kinetic energy. The transport equation for the SGS turbulent kinetic energy is utilized [3]. The SGS turbulent kinetic energy accounts for the history and non-local effects, and has the potential to benefit complex flows with non-equilibrium turbulence. We employ the finite difference scheme in order to solve the transport equation on the same computational grid that is used in the lattice Boltzmann method. The only link between the transport equation and the lattice Boltzmann dynamics is through the SGS eddy-viscosity relation.

Simulation results are presented for the turbulent flow over a backwards facing step. We compare reattachment legth obtained by the present method, the method using the conventional Smagorinsky model, and experiment.

REFERENCES

[1] Suga K., Kuwata Y., Takashima K., and Chikasue R. A D3Q27 multiple-relaxation-time lattice Boltzmann method for turbulent flows. *Computers and Mathematics with Applications*, Vol. **69**, pp. 518–529, (2015).

[2] Dong Y-H and Sagaut, P. A study of time correlations in lattice Boltzmann-based large-eddy simulation of isotropic turbulence. *Physics of Fluids*, Vol. **20**, pp. 035105 1–11, (2008).

[3] Taghinia, J. and Rahman, M.M. Large eddy simulation of round impinging jet with one-equation subgrid scale model. *Int. J. Heat and Mass Transfert*, Vol. **116**, pp. 1250–1259, (2018).