Lattice Boltzmann Flux Solver for Simulation of Hypersonic Flows

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ABSTRACT

In this paper, a stable Lattice Boltzmann Flux Solver (LBFS) is proposed for simulation of hypersonic flows. Lattice Boltzmann method (LBM) is a research focus due to its kinetic nature, simplicity, and easy implementation. However, LBM is not suitable for incompressible flows. In LBFS, the finite volume method is applied to solve the Navier-Stokes equations. One-dimensional Lattice Boltzmann model is applied to reconstruct the inviscid flux across the cell interface, while the viscous flux is solved by conventional smooth approximation function. The present work overcomes the existing LBFS problem which is unable to calculate hypersonic flow field on the leeward because of the large effects from low pressure area. Simulation of a double cone configuration is studied. It is discovered that the tail area of double cone is related to the maximum Mach number that could be convergent. The larger the diameter of tail area is, the smaller Mach number could be convergent. Hence, the low pressure area behind double cone tail will have large effects during the LBFS simulation of hypersonic flow. Two measurements are applied in this paper to overcome the low pressure problem. The first one is to apply a local block grid refinement method based on the flow conditions for improving the stability. The second is to add a constraint parameter to eliminate negative value and give out a proper one. Hence, LBFS is able to get convergent result of the hypersonic flow field on both windward and leeward. Several numerical examples are tested to compare the performance of method presented in this paper. Simulation results show that method present in this paper is able to calculate hypersonic flow field on the leeward with both fine accurate and efficient.

REFERENCES

[1] L. M. Yang, C. Shu and J. Wu, *A Hybrid Lattice Boltzmann Flux Solver for Simulation of Viscous Compressible Flows*, Advances in Applied Mathematics and Mechanics, Vol. 8, No.6, pp. 887-910, (2016).