Modified Lattice Boltzmann Method for Compressible Fluid Simulations

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Abstract

A modified lattice Boltzmann algorithm is shown to have much better stability to growing temperature perturbations, when compared with the standard lattice Boltzmann algorithm. The damping rates of long wavelength waves, which determine stability, are derived using a collisional equilibrium distribution function which has the property that the Euler equations are obtained exactly in the limit of zero time step. Using this equilibrium distribution function, we show that the new algorithm has inherent positive hyperviscosity and hyperdiffusivity, for very small values of viscosity and thermal diffusivity, which is lacking in the standard algorithm. Short wavelength modes are shown to be stable for temperatures greater than a lower limit. Results from a computer code are used to compare these algorithms and to confirm the damping rate predictions made analytically. Finite amplitude sound waves in the simulated fluid steepen as expected from gas dynamic theory.

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