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Prandtl number effects in MRT Lattice Boltzmann models for shocked and unshocked compressible fluids

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For compressible fluids under shock wave reaction, we have proposed two Multiple-Relaxation-Time (MRT) Lattice Boltzmann (LB) models [F. Chen, et al, EPL \textbf{90} (2010) 54003; Phys. Lett. A \textbf{375} (2011) 2129.]. In this paper, we construct a new MRT Lattice Boltzmann model which is not only for the shocked compressible fluids, but also for the unshocked compressible fluids. To make the model work for unshocked compressible fluids, a key step is to modify the collision operators of energy flux so that the viscous coefficient in momentum equation is consistent with that in energy equation even in the unshocked system. The unnecessity of the modification for systems under strong shock is analyzed. The model is validated by some well-known benchmark tests, including (i) thermal Couette flow, (ii) Riemann problem, (iii) Richtmyer-Meshkov instability. The first system is unshocked and the latter two are shocked. In all the three systems, the Prandtl numbers effects are checked. Satisfying agreements are obtained between new model results and analytical ones or other numerical results.

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