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Simulating oscillatory flows in Rayleigh-Bénard convection using the lattice Boltzmann method. (English) Zbl 1119.76048

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Summary: Rayleigh-Bénard convection is a fundamental phenomenon found in many atmospheric and industrial applications. Many numerical methods have been applied to analyze this problem, including the lattice Boltzmann method (LBM), which has emerged as one of the most powerful computational fluid dynamics (CFD) methods in recent years. Using a simple LB model with the Boussinesq approximation, this study investigates the 2D Rayleigh-Bénard problem from the threshold of the primary instability with a theoretical value of critical Rayleigh number $Ra_c = 1707.76$ to the regime near the flow bifurcation to the secondary instability. Since the fluid of LBM is compressible, an appropriate velocity scale for natural convection is carefully chosen at each value of the Prandtl number to ensure that the simulations satisfy the incompressible condition. The simulation results show that periodic unsteady flows take place at certain Prandtl numbers with an appropriate Rayleigh number. Furthermore, the Nusselt number is found to be relatively insensitive to the Prandtl number in the current simulation ranges of $0.71 \leq Pr \leq 70$ and $Ra \leq 10^5$. Finally, the relationship between the Nusselt number and the Rayleigh number is also investigated.

MSC:

76M28 Particle methods and lattice-gas methods
76R10 Free convection
76F35 Convective turbulence

Cited in **9** Documents

Keywords:

Rayleigh-Bénard convection; natural convection; lattice Boltzmann method (LBM); computational fluid dynamics (CFD)

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