A research of multi-component extensions of the Lattice Boltzmann Method

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Abstract

The Lattice Boltzmann Method (LBM), which simulates fluid flows by calculations of the simplified molecular dynamics, has been studied. LBM is able to analyze fluids more accurately than traditional techniques (e.g., Navier-Stokes equation, etc.), and has been applied for multi-phase flow analysis and so on. In addition, LBM is implemented to ranges from workstation to massively parallel computer by simplicity of its algorithm. However, works related to miscible multi-phase flow analysis in LBM often limit the number of phases and lack the consideration of thermal fluids. Therefore, this paper proposed four extension methods of LBM in order to simulate multi-phase flow including the consideration of thermal fluids without limited number of phases. These extension methods are able to lead miscible multi-phase flow models from any single-phase flow model, and to simulate thermal miscible multi-phase flow. The following list shows the characteristic of these four extension methods.

1. **Multi-Component Extension Method (MCEM)** leads multi-phase flow models with homogeneous material properties (excluding density).
2. **Mixture Multi-component Extension (MME)** leads multi-phase flow models with different material properties, however, which is hard to analyze each phase strictly.
3. **Multi-component Interaction eXtension (MIX)** leads multi-phase flow models with different material properties, which is able to analyzes each phase strictly.
4. **REaction Multi-component Interaction eXtension (REMIX)** is an extension of MIX and able to analyze chemical reactions, etc.

This paper shows that these methods satisfied quantities conservation and led valid results, and then that these methods are able to simulate convection and molecular diffusion simultaneously, which is hard to simulate by traditional techniques. In the benchmark of REMIX on Cray T3E, the parallel performance of REMIX was just the same as it of general LBM.

Key Words: **Computational Fluid Dynamics, Lattice Boltzmann Method, Multi-phase flow, miscible multi-phase flow, thermal fluid, extension of LBM**