

Advances in the kinetics of heat and mass transfer in near-continuous complex flows

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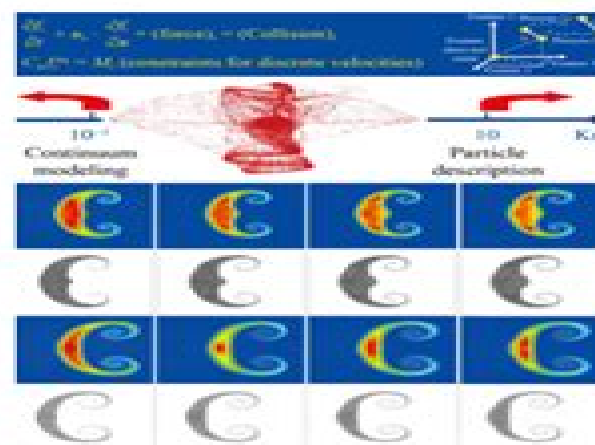
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Received November 10, 2023; accepted December 24, 2023

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ABSTRACT

The study of macro continuous flow has a long history. Simultaneously, the exploration of heat and mass transfer in small systems with a particle number of several hundred or less has gained significant interest in the fields of statistical physics and nonlinear science. However, due to absence of suitable methods, the understanding of mesoscale behavior situated between the aforementioned two scenarios, which challenges the physical function of traditional continuous fluid theory and exceeds the simulation capability of microscopic molecular dynamics method, remains considerably deficient. This greatly restricts the evaluation of effects of mesoscale behavior and impedes the development of corresponding regulation techniques. To access the mesoscale behaviors, there are two ways: from large to small and from small to large. Given the necessity to interface with the prevailing macroscopic continuous modeling currently used in the mechanical engineering community, our study of mesoscale behavior begins from the side closer to the macroscopic continuum, that is from large to small. Focusing on some fundamental challenges encountered in modeling and analysis of near-continuous flows, we review the research progress of discrete Boltzmann method (DBM). The ideas and schemes of DBM in coarse-grained modeling and complex physical field analysis are introduced. The relationships, particularly the differences, between DBM and traditional fluid modeling as well as other kinetic methods are discussed. After verification and validation of the method, some applied researches including the development of various physical functions associated with discrete and non-equilibrium effects are illustrated. Future directions of DBM related studies are indicated.

Keywords near-continuous flow, non-equilibrium, kinetics, discrete Boltzmann method, complex physical field analysis



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