Editorial

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Biographical notes: Li-Shi Luo is currently the Richard F. Barry Jr. Distinguished Endowed Professor at Department of Mathematics and Statistics, Old Dominion University. He obtained his PhD degree in physics from Georgia Institute of Technology in 1993. Before joining ODU in 2004, he worked in Los Alamos National Laboratory, Worcester Polytechnic Institute, ICASE/NASA Langley Research Center, and National Institute of Aerospace. His main research interests include kinetic theory, nonequilibrium flows, complex fluids, kinetic/mesoscopic methods for computational fluid dynamics, and scientific computing.

Manfred Krafczyk obained his Master's degree in physics in 1991 from the University of Dortmund. He was awarded a SIEMENS PhD scholarship and obtained his PhD degree in the Department of Civil Engineering at the University of Dortmund in 1995, with a thesis on Lattice-Gas methods. In Spring of 2001, he completed his habilitation thesis on Lattice-Boltzmann methods in the Techical University of Munich. In the same year he joined the Technical University of Braunschweig as a full Professor and the Director of the Institute for Computational Modelling in Civil Engineering. His research interests include kinetic methods, transport phenomena, computational fluid dynamics, distributed and high performance computing, numerical methods and computer visualisation.

Matter, conceptually classified into fluids and solids, can be completely described by the microscopic physics of its constituent atoms or molecules. However, for most engineering applications a macroscopic or continuum description has usually been sufficient, because of the large disparity between the spatial and temporal scales relevant to these applications and the scales of the underlying molecular dynamics. In this case, the microscopic physics merely determines material properties such as the viscosity of a fluid or the elastic constants of a solid. These material properties cannot be derived within the macroscopic framework, but the qualitative nature of the macroscopic dynamics is usually insensitive to the details of the underlying microscopic interactions.

The traditional picture of the role of microscopic and macroscopic physics is now being challenged as new multiscale and multi-physics problems begin to emerge. For example, in nano-scale systems, the assumption of scale separation breaks down; macroscopic theory is therefore inadequate, yet microscopic theory may be impractical because it requires computational capabilities far beyond our present reach. This new class of problems poses unprecedented challenges to mathematical modelling as well as numerical simulation and requires new and non-traditional analysis and modelling paradigms. Methods based on mesoscopic theories connecting the microscopic and macroscopic descriptions of the dynamics provide a promising approach. They can lead to useful models, possibly requiring empirical inputs to determine some of the model parameters, which are sub-macroscopic, yet indispensable to the relevant physical phenomena. An important challenge will be to construct meaningful mesoscopic models by extracting all the macroscopically relevant information from the microscopic dynamics.

There already exist mesoscopic methods such as the Lattice Gas Cellular Automata (LGCA), the Lattice Boltzmann Equation (LBE), Discrete Velocity Models (DVM) of the Boltzmann equation, Gas-Kinetic Schemes

(GKS), Smoothed Particle Hydrodynamics (SPH) and Dissipative Particle Dynamics (DPD). Although these methods are sometimes designed for macroscopic hydrodynamics, they are not based upon the Navier-Stokes equations; instead, they are closely related to kinetic theory and the Boltzmann equation. These methods are promising candidates to effectively connect microscopic and macroscopic scales and thereby substantially extend the capabilities of numerical simulations. For this reason, they are the focuses of the International Conferences on Mesoscopic Methods in Engineering and Science (ICMMES, http://www.icmmes.org).

The Third ICMMES Conference was held in Hampton, Virginia, 24–28 July, 2006. The ICMMES-2006 was organised by the Department of Mathematics and Statistics, Old Dominion University, Norfolk, Virginia. This special issue of the *Progress in Computational Fluid Dynamics* devoted to this conference includes 21 selected papers mainly focusing on the LBE method, its theory, implementation and applications. The maturity and usefulness of the kinetic methods are attested by the wide range of applications and the qualities of these simulations.

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