Motivation

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Matter, conceptually classified into fluids and solids, can be fully described by the microscopic physics of its constituent molecules or particles. However, for most engineering applications, a macroscopic or continuum description has usually been sufficient. The macroscopic / continuum approach is successful because there is a great disparity between the macroscopic spatial and temporal scales relevant to these applications and the corresponding microscopic scales. Microscopic dynamics merely determines material properties like the transport coefficients of a fluid or the elastic moduli of a solid, which cannot be derived within the macroscopic framework. The macroscopic dynamics is therefore insensitive to the details of the underlying microscopic dynamics; indeed, if the material properties are simply measured experimentally, then the microscopic dynamics is largely irrelevant.

This traditional picture of the role of microscopic and macroscopic physics is now being challenged as new multi-scale and multi-physics problems have begun to emerge in many fields. For example, in nano-scale systems, the scale separation assumption does not hold; 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 and numerical simulation and requires new and nontraditional modeling and analysis paradigms. Methods based on mesoscopic theories, which connect 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 adequate to simulate the relevant physical phenomena. An important challenge will be to construct such mesoscopic models by identifying the optimal minimal relevant information from the microscopic dynamics.

The mission of this ***International Conference*** Series on ***Mesoscopic Methods in Engineering and Science*** is to bring together researchers and practitioners in various engineering and scientific fields to focus on the emerging methods based on mesoscopic theory and computational mathematics and algorithms required by the new kinetic approaches. Notable examples include the Lattice Gas Cellular Automata (LGCA), the Lattice Boltzmann Equation (LBE), the Discrete Velocity Models (DVM), the Gas-Kinetic Scheme (GKS), the Dissipative Particle Dynamics (DPD), and the Smoothed Particle Hydrodynamics (SPH). Although these methods are sometimes designed for macroscopic hydrodynamics, they are not based upon macroscopic equations like 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 physics and thereby substantially extend our computational and analytical capabilities.