Center for Quantum Science and Engineering (CQSE)

Weekly Seminar
Jun. 3, 2011 (Friday)

TIME Jun. 3, 14:30 ~ 15:30

TITLE Lattice-Boltzmann Modeling of Phonon Boltzmann Equation and Heat-conduction Equations

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Abstract

The transport of heat described by the classical Fourier's law of heat conduction has been demonstrated to give rise to unreasonable results in a number of situations. Several relaxation based models that, for example, lead to the wave-based heat conduction and dual-phase-lag heat conduction equation, have been proposed to resolve this dilemma. However, these equations either possess unusual features or predict controversial results especially at the mesocopic regimes. Microscopically, transport of heat in a dielectric solid is accomplished through atomic vibrations that travel within the solid as waves. The energy of the waves can be quantized as phonons and the solid medium can be treated as phonon gas. The Boltzmann equation is one of the effective tools to describe phonon interactions. Phonon propagation modes can either be classified as the individual propagation modes that include the ballistics and diffusion modes or as the collective propagation modes which cover the second sound and heat conduction modes. In this talk, the macroscopic heat conduction equation based on the phonon Boltzmann equation, involving both N (normal) and U (umklapp) processes, will be first demonstrated through the Chapman-Enskog multiscale expansion. Fundamental differences in transport phenomena of heat between the phonon-Boltzmann-based heat conduction equation and the dual-phase-lag-based heat conduction are examined and discussed by two numerical examples: the transient behavior of a thermal pulse propagating in a single-phased medium; and, both the transient and the steady-state transport phenomena on a two-layered structure subjected to different temperatures at boundaries.