Modal Galerkin methods with applications for transport problems

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In this talk, we consider the development of the numerical methods for solving Boltzmann-Curtiss kinetic equation for gas flows and Quantum Boltzmann kinetic equation for solids in semiconductor devices. The classical description based on the first-order Navier-Stokes-Fourier (NSF) constitutive laws has serious limitations in predicting the correct flow behavior of gases in thermal nonequilibrium. As a consequence, simple modification of transport coefficients in the classical NSF theory or introduction of the velocity-slip and temperature-jump boundary conditions cannot solve the current bottleneck of problems in the study of gas flows in non-equilibrium. In order to cope with these deficiencies, a non-classical theory based on the second-order Boltzmann–Curtiss constitutive relations for diatomic and polyatomic gases was studied. An important result obtained in these studies is that constitutive relations between stresses and the strain rate are generally nonlinear and coupled in states far from thermal equilibrium. On the other hand, Quantum Boltzmann kinetic equation represents a way of describing the time evolution of a system consisting of a large number of particles (electrons or phonons). Due to the high number of dimensions and their intrinsic physical properties, the construction of numerical methods represents a challenge and requires a careful balance between accuracy and computational complexity. Among traditional high-order methods, the discontinuous Galerkin methods have received increasing attention as a numerical technique for predicting the flow behavior of gas dynamics problems. In this present work, we proposed a multi-dimensional explicit modal discontinuous Galerkin method based on structured/unstructured meshes for solving Boltzmann-Curtiss kinetic equation as well Quantum-Boltzmann transport equation. The performance of this numerical scheme is assessed by solving several well-known problems

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