The Hong Kong University of Science and Technology

Department of Mathematics

PhD THESIS EXAMINATION

Unified Gas-kinetic Wave-particle Method for Multiscale Flow Modeling and Computation

By

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ABSTRACT

In this thesis, the unified gas-kinetic wave-particle (UGKWP) method for monatomic and diatomic gas flow simulations has been constructed on three-dimensional unstructured mesh with parallel computing capability. The time evolution in the UGKWP method is composed of analytical wave and stochastic particles, where the accumulating effect from particle transport and collision is modeled on the mesh size scale within a time step. With the dynamic wave-particle decomposition, the UGKWP method is able to capture the continuum wave interaction and rarefied particle transport without resolving down to the kinetic scale. In addition, UGKWP achieves high efficiency in different flow regimes. As the local cell's Knudsen number varies, the UGKWP automatically becomes a particle method in the highly rarefied flow regime and the gas-kinetic scheme (GKS) without particles in the continuum flow regime. In UGKWP, a heuristic modeling on particle collision time according to particle velocity is implemented. As a result, the novel modeling dramatically improves the performance of UGKWP in capturing non-equilibrium effects for both monatomic and diatomic gas flows, whereas its accuracy in the continuum regime is still retained. In summary, the UGKWP method has great potential in simulating three-dimensional multiscale transport with the coexistence of continuum and rarefied flow regimes, particularly for high-speed non-equilibrium flow surrounding a spacecraft in near-space flight.

Date : 9 December 2021, Thursday

Time : 10:00 a.m.

Venue : Room 1409 (Lifts 25-26)
1/F Academic Building, HKUST

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The student's thesis is now being displayed on the reception counter in the General Administration Office (Room 3461).