The Hong Kong University of Science and Technology

Department of Mathematics

PhD THESIS EXAMINATION

High-order Gas-kinetic Schemes under Finite Difference and Spectral Difference Frameworks

By

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ABSTRACT

This thesis is about the construction of high-order gas-kinetic schemes (HGKS) under difference frameworks for the Euler and Navier-Stokes equations. The gas-kinetic scheme (GKS) is based on the time-accurate evolution solution of kinetic model equation. Firstly, the conservative finite difference HGKS is constructed, where the flux function at node point is kinetically split and utilized to achieve high-order spatial accuracy through WENO-type reconstruction. The two-stage fourth-order (S2O4) time stepping method is used for the high-order temporal discretization, where the derivatives required in S2O4 are obtained directly from the time-accurate GKS flux function. The accuracy and robustness of the scheme have been validated through flow problems with vortex propagation and shock interaction. The efficiency test regarding the CPU time vs. the errors shows that the current scheme is more efficient than the same order finite volume version of HGKS. Secondly, the spectral difference gas-kinetic scheme (SDGKS) is successfully developed on unstructured quadrilateral mesh with the implementation of S2O4 time marching method as well. The efficiency of SDGKS is higher than that of traditional schemes for viscous flow computation. Stability analysis for the scheme on the linear advection solution shows that the new scheme is linearly stable. The computational results from the scheme agree well with the analytic and reference solutions.

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