The Hong Kong University of Science and Technology

Department of Mathematics

PhD THESIS EXAMINATION

Development of High-Order Shock-Capturing Methods for Hyperbolic Conservation Laws

By

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ABSTRACT

PDEs have been widely applied in various research fields, including electronic and information engineering, oceanography, atmospheric science, and aerospace engineering. Hyperbolic conservation laws are a special form of PDEs and widely applied for simulating compressible flows, describing the principles of wave propagation, in which their nonlinear nature underpins its non-triviality. One of the major challenges is the prediction of locations and occurrences of discontinuities, where owing to the Gibbs phenomenon, conventional high-order schemes produce spurious oscillations near discontinuities. In this thesis, a series of advanced high-order numerical methods with low dissipation is introduced for compressible flows: (1) A novel TENO5-A scheme is proposed to determine the cut-off parameter based on the local wavenumber detected by a new five-point scale sensor, whereas the original TENO5-A scheme adopts the cut-off parameter roughly according to the locations of discontinuities; (2) While the TENO-family schemes have been widely utilized with finite-difference and finite-volume frameworks, RKDG methods possess the advantage of ensuring high-order accuracy with a compact stencil. Therefore, a new troubled cell indicator and nonlinear limiter are proposed based on the TENO schemes, showcasing the first application of TENO schemes with RKDG methods; (3) To minimize the numerical dissipation of TENO schemes for RKDG methods, the THINC reconstruction is implemented to resolve discontinuities. However, the TENO troubled cell indicator only detects non-smooth regions. A BVD strategy is proposed to apply the TENO scheme for high-wavenumber fluctuations and the THINC reconstruction for discontinuities; (4) The TENO limiter for the RKDG methods is extended to unstructured meshes. A novel weighting strategy is proposed to obtain the final reconstructed numerical solution from the candidate numerical solutions at each interface according to their smoothness, instead of the conventional approach where the areas of the neighbouring cells are used.

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***Thesis Examination Committee*:**

Chairman	**:**	**Prof. Yue ZHENG, ACCT/HKUST**
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(Open to all faculty and students)

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