Recent Progress in Limiting Strategy for Multi-dimensional Conservation Laws

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ABSTRACT

The present work is about an efficient and accurate limiting strategy for multi-dimensional conservation laws on structured and unstructured grids. Most oscillation-free schemes including TVD, TVB, ENO and WENO are mainly based on the mathematical analysis of one-dimensional convection equation, and applied to systems of equations with the help of some linearization step. Though this approach may work successfully in many cases, it is often insufficient or almost impossible to control oscillation near shock discontinuity in multi-dimensional flow. For that reason, the need to explore an oscillation control method for multi-dimensional applications is manifest.

In order to find out a suitable criterion for oscillation-control in multiple dimensions, the one-dimensional monotonic condition was extended to multi-dimensional space and multi-dimensional limiting process (MLP) was successfully formulated on structured grids. Although the basic framework of MLP on structured grid is TVD MUSCL approach, there is a significant difference in limiting strategy. While TVD limiting region is fixed, the MLP limiting region is adaptive according to multi-dimensional flow physics. Thus, MLP limiting is more effective to control oscillations near multi-dimensional discontinuity, and it shows remarkably enhanced accuracy and convergence characteristics for numerous inviscid and viscous computations.

Moreover, this strategy has been also extended to unstructured grids on which the multi-dimensional limiter is more important due to the geometric complexity (or multi-dimensionality) of non-aligned meshes. With the key idea of MLP on structured grids, the MLP for unstructured grids can similarly control vertex values in order to satisfy the maximum principle. In full paper, we are going to introduce the physical/mathematical rationale of MLP limiting strategy, the results of various numerical test cases, and the characteristics of MLP on structured and unstructured grids in detail.