HIGHER ORDER DISCONTINUOUS GALERKIN METHODS WITH EMPHASIS ON AERONAUTICAL APPLICATIONS

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ABSTRACT

Over past years Discontinuous Galerkin (DG) methods have been perceived as a viable way to go beyond second-order accurate discretizations of PDEs on general unstructured and even polyhedral grids. In turn, the achievements of DG methods in several fields of computational physics have fostered research on new high-order methods and on the extension of already existing methods to higher order accuracy.

In this lecture we present recent developments and high-order numerical results of a DG method applied to compute transonic turbulent flows around aerodynamic shapes. The flow model here employed is described by the Reynolds-Averaged Navier-Stokes (RANS) equations equipped with the two-equation k-ω turbulence model. To a large extent, the material presented in this lecture summarizes our advances on the DG method achieved within the EU-funded ADIGMA project. The combination of high-order discretization, equations stiffness and flow discontinuities makes the DG solution of the RANS and k-ω equations for high Reynolds number transonic flows very challenging.

In fact, the discretization should preserve high-order accuracy on highly stretched and curved grids, the shock-capturing technique should be able to provide sub-cell resolution of discontinuities while having minimal impact away from shocks, time integration should be robust and efficient. Several promising approaches to address each of these topics have been presented in the published literature and have been demonstrated on simple test cases as well as on ever more complex applications.

The main focus of the lecture will be on recent advances in the above topics. Relative advantages of modal and nodal expansion bases for the DG discretization on highly stretched and curved elements will be discussed. The control of oscillations around shocks by means of a directional shock-capturing term, with an amount of artificial viscosity controlled by the jump of the interface inviscid flux, will be demonstrated for both inviscid and turbulent flows. The implicit time integration of the fully coupled DG-discretized RANS and k-! equations will be presented in some detail together with several highorder DG results of 2D and 3D transonic turbulent test cases proposed within the ADIGMA project.

The final part of the lecture will touch upon recent results of the p-multigrid DG solution of the RANS and k-ω equations and on the development of the DG discretization for general polyhedral grids as a preliminary step for an agglomeration h-multigrid technique.

REFERENCES

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