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ADVANCES IN SHOCK CAPTURING STRATEGIES FOR HIGH ORDER METHODS

TRACK NUMBER 2000: COMPUTATIONAL FLUID DYNAMICS

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ABSTRACT

High order methods like Discontinuous Galerkin, Flux Reconstruction, High order Finite Volume methods and related approaches have provable rapid convergence for smooth solutions. In compressible fluid flows, shock waves or other (near) discontinuities can occur, which are ill-suited for a high order polynomial approximation and trigger Gibb's oscillations. Stable numerical approximations of these phenomena requires thus either a) a localized change of the discretization operator or b) the smoothening of the discontinuity to make it tractable by a high order scheme. Both approaches can also benefit from an associated grid refinement towards the shock. In any case, applying these shock capturing efforts should be limited in scope in order to avoid excessive numerical damping (in particular when interaction with turbulence occurs) and to keep algorithmic costs to a minimum.

This requirement necessitates efficient and accurate detection of occurring shocks based on the discrete flow solution. Since numerical schemes differ in their inherent stability and robustness, indicators typically need to be tuned for a given scheme and a given flow problem – relying purely on physical considerations disregards the different "character" of numerical discretizations in underresolved settings. Some recent advances based on a posteriori detection and shock capturing can help alleviate this problem; in addition, data-based approaches have been shown to reduce the manual parameter tuning significantly.

A second difficulty for shock capturing in high order settings stems from the use of coarse grids with comparably large elements which clashes with the need to localize shocks on the sub-element scale of $\triangle x/p$. This can be tackled by introducing a sub-element grid and local discretization, by h/p/r-refinement strategies, shock front tracking methods or localized shock

smoothing. While the later are easier to implement, the former ones usually lead to sharper shock fronts at increased algorithmic complexity. In any case, the need to capture shocks on a high order grid introduces a local change in the approximation properties; the thereby introduced inhomogeneity can pose significant challenges in the presence of “weaker” scales like acoustics or turbulence.

This minisymposium brings together researchers focused on developing algorithms for shock detection and stabilization techniques for high order methods. Contributions in the field of “classical” shock capturing and data-driven approaches will accompany each other such that mutual interactions are highlighted.

PLANNED TALKS WITH TENTATIVE TITLES

The following researchers have already agreed to give a talk at the planned minisymposium:

- Joaquim Peiro (Imperial College London): “Shock-capturing for high-order discontinuous Galerkin solvers”
- Svetlana Tokareva (Los Alamos National Laboratory): “Matrix-free finite element approximations for high-order shock capturing”
- Florian Kummer (University of Darmstadt): “An extended discontinuous Galerkin method for high-order shock treatment”
- Deep Ray (University of Southern California): “p-adaptivity strategies using deep learning”
- Jonas Zeifang (University of Hasselt) and Andrea Beck (University of Magdeburg): “Data-Driven artificial viscosity shock capturing for the discontinuous Galerkin spectral element method”

We are aiming for inviting more researchers to give a talk and are therefore looking forward to welcome additional speakers to the minisymposium.