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OPTIMIZED ACCELERATED IMPLICIT-EXPLICIT SCHEMES FOR HIGH-ORDER UNSTRUCTURED METHODS

Brian C. Vermeire[1,*] and Siavash H. Nasab[2]

[1] Assistant Professor, Department of Mechanical, Industrial, and Aerospace Engineering, Concordia University, Montreal, QC, Canada, brian.vermeire@concordia.ca
[2] PhD Candidate, Department of Mechanical, Industrial, and Aerospace Engineering, Concordia University, Montreal, QC, Canada

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The ability to perform scale-resolving simulations of wall bounded turbulent flows via Large Eddy Simulation (LES) and Direct Numerical Simulation (LES) requires accurate, efficient, and stable space-time discretizations. High-order unstructured spatial discretizations, such as the Flux Reconstruction (FR) [1] and Discontinuous Galerkin (DG) approaches, are particularly appealling. However, the wall resolution requirements of high Reynolds number flows induces significant numerical stiffness. This typically limits fully-explicit schemes to moderate Reynolds numbers ($Re < 10^6$). In contrast, the computational cost and memory requirements of fully-implicit schemes can be prohibitive for FR and DG. The use of Implicit Explicit (IMEX) schemes with FR/DG has been shown to alleviate the stability restrictions of explicit methods and requires a fraction of the memory of fully-implicit methods, making them appealing for LES/DNS [2].

In this work we will present a new family of Accelerated IMEX (AIMEX) schemes. These are optimized for FR/DG and allow us to take arbitrarily large time-steps by increasing the number of stages and optimizing the explicit part of the scheme. Importantly, this is achieved without increasing the number of implicit stages per time step, which often dominate the cost of the IMEX approach. Hence, we are able to take significantly larger time steps than classical IMEX schemes, reducing the total computational cost of a simulation. We will demonstrate the time-accuracy of the AIMEX approach and its utility for solving the unsteady Navier-Stokes equations with high-order unstructured methods. Finally, we will provide a demonstration of the application of AIMEX schemes to wall-resolved LES with FR.

REFERENCES

[1] Huynh, H.T. A flux reconstruction approach to high-order schemes including discontinuous Galerkin methods. AIAA 2007-4079, (2007).

[2] Vermeire, B.C. and Nadarajah, S. Adaptive IMEX schemes for high-order unstructured methods. *Journal Comp. Physics* (2015) **280**, pp. 261–286.