The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Efficient time marching methodologies for a p–adaptive Discontinuous Galerkin approximation

Gerasimos Ntoukas[1a] , **Wojciech Laskowski**[1], **Gonzalo Rubio**[1,2] **and Esteban Ferrer**[1,2]

[1] ETSIAE-UPM - School of Aeronautics, Universidad Politécnica de Madrid,
Plaza Cardenal Cisneros 3, E-28040 Madrid, Spain,
email[a]: gerasimos.ntoukas@upm.es

[2] Center for Computational Simulation, Universidad Politécnica de Madrid,
Campus de Montegancedo,Boadilla del Monte,28660 Madrid,Spain

Keywords: *Discontinuous Galerkin, RANS, High–Order Methods, Mesh refinement, P-adaptivity, convergence acceleration*

The objective of this work is to present modern acceleration techniques for different types of flows in the context of higher–order–methods. Multigrid methods constitute a significant component for the speed–up of numerical simulations. Fast steady-state solvers are essential for various types of fluid flow solvers (e.g., RANS solvers or unsteady flows based on dual time stepping that can be used for compressible Navier-Stokes or multiphase flow applications). Some of the most popular and efficient techniques up to date consist of coarse grid acceleration in combination with semi–implicit smoothers [1]. More specifically, for higher–order–methods, a natural choice is p–multigrid since the coarser levels are obtained by reducing the approximation order of the solution [2]. The numerical framework in this work consists of a compressible Navier-Stokes solver complimented with the Spalart–Allmaras turbulence model, approximated with a high–order discontinuous Galerkin spectral element method. We analyze the performance of several popular relaxation strategies for multigrid: explicit Runge-Kutta methods with local time stepping, smoothers with local or block LU factorization (e.g. block–Jacobi) and smoothers with incomplete factorization (e.g. ILU(k)) on representative test cases, such as the flow past an airfoil. In addition, through the method of p–adaptation, a characteristic of higher–order–methods, we aim to further accelerate the simulation and reduce the associated computational cost through element–local adaptation of the polynomial order [3].

References

[1] Antonio Ghidoni, Alessandro Colombo, Francesco Bassi, and Stefano Rebay. Efficient p-multigrid discontinuous galerkin solver for complex viscous flows on stretched grids. *International Journal for Numerical Methods in Fluids*, 75(2):134–154, 2014.

[2] Krzysztof J Fidkowski, Todd A Oliver, James Lu, and David L Darmofal. p-multigrid solution of high-order discontinuous galerkin discretizations of the compressible navier–stokes equations. *Journal of Computational Physics*, 207(1):92–113, 2005.

[3] Andrés M Rueda-Ramírez, Juan Manzanero, Esteban Ferrer, Gonzalo Rubio, and Eusebio Valero. A p-multigrid strategy with anisotropic p-adaptation based on truncation errors for high-order discontinuous galerkin methods. *Journal of Computational Physics*, 378: 209–233, 2019.