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IMPLEMENTATION OF A HYBRID RANS-LES APPROACH IN AN IMPLICIT VERY HIGH-ORDER DISCONTINUOUS GALERKIN SOLVER

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In recent years, hybrid approaches between Reynolds-Averaged Navier–Stokes (RANS) and Large-Eddy Simulation (LES) have been gaining interest for their use in high-fidelity simulations of massively separated flows at industrially meaningful Reynolds numbers. Such modeling approach is intended as a way to go beyond the known lacks of the RANS approach in simulating massively separated flows and the computational limitations that nowadays make LES still too demanding for a practical use.
In this paper we present the main features of our implicit implementation of the eXtra-Large Eddy Simulation (X-LES) model of Kok *et al.* [1] in the Discontinuous Galerkin (DG) solver named MIGALE [2]. In the X-LES approach a composition of the two-equation TNT $k-\omega$ [3] turbulence model and a k-equation subgrid-scale model (SGS) is used.
Turbulent quantities equations have been discretized to a high-order spatial accuracy consistently with the mean flow. An accurate discretization on hybrid type, highly-stretched and curved, elements is obtained by using hierarchical and orthonormal polynomial basis functions local to each element and defined in the physical space [4].
The time-accurate integration of the fully coupled system of governing equations is performed by means of linearly implicit Rosenbrock-type Runge–Kutta methods [5], where the exact Jacobian is derived analytically and the linear system is solved by means of the GMRES algorithm preconditioned with the Block Jacobi method or the Additive Schwarz

Method, using the PETSc library [6, 7].
Assessment and validation of our implementation will be performed by computing external aerodynamics problems that involve massively separated flows, *e.g.*, the flow around a delta wings.

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