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IMPLICIT LES OF TURBULENT FLOWS USING A DISCONTINUOUS GALERKIN METHOD

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In the near future the use of *Large Eddy Simulation (LES)* or even *Direct Numerical Simulation (DNS)* will become ever more widespread, e.g. for the prediction of flow instabilities and noise generation, or even simply the global performance of flow machinery. However, the use of these approaches requires highly resolved computations. Therefore, the discretisation method should feature a high order of convergence, as well as excellent parallel scaling to tackle the huge resolution requirements. An additional difficulty stems from the geometrical complexity of industrial geometries. Recently *finite element (FEM)*-like high-order methods such as *discontinuous Galerkin (DGM)* [1,2], *spectral difference (SDM)* [3,4] and *spectral element (SEM)* [5,6] methods have been applied to such computations. The main motivation is that these methods bridge the gap between the high accuracy - deemed indispensable for adequate resolution of the turbulent structures - of academic solvers and the geometric flexibility of industrial solvers. In addition to very interesting dispersion and dissipation properties, DGM furthermore provides computational efficiency and a simple way of checking grid resolution without requiring additional computations. These advantages potentially make DGM a powerful tool for high fidelity simulation of transitional and turbulent flows.

An implicit time-integration DGM compressible flow solver has been successfully validated in previous studies for DNS computations [1]. Here, the ability of the method to perform LES is assessed on canonical test cases such as homogeneous isotropic turbulence at infinite Reynolds and channel flows from $Re_\tau = 395$ to 950 (Figure 1). It is shown that accurate results can be obtained using implicit LES (ILES). Indeed, the dissipation of the discretisation is sufficient to damp the smallest resolved structures of the flow without altering the larger ones. Finally, the method is further evaluated on more complex geometries such as the transitional flow around low Reynolds airfoils (Eppler E387 and SD7003, $Re = 60k$ with low angle of attack) [2], and the two-dimensional periodic hill

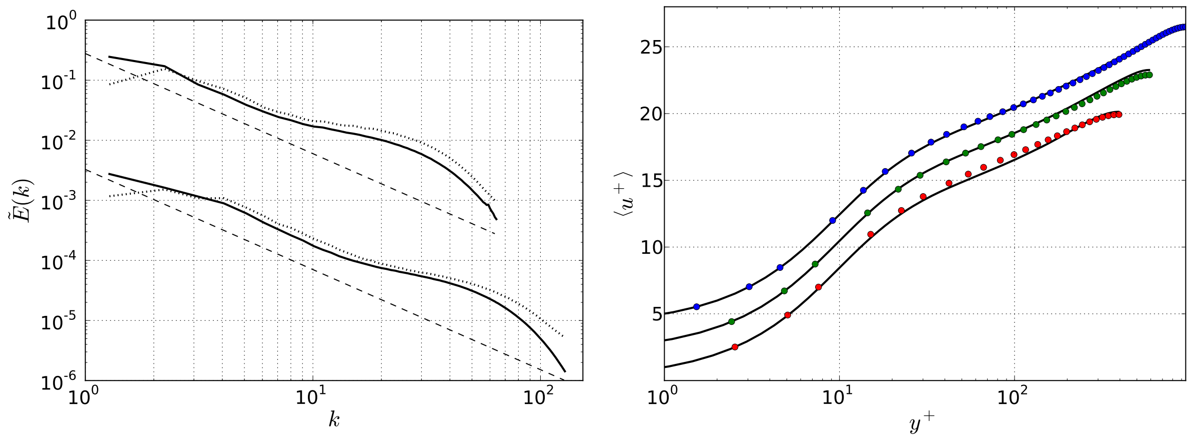

Figure 1: Left: energy spectrum of the HIT at infinite Reynolds for two grid sizes. DGM/ILES (solid line) compared to pseudo-spectral method using variational multiscale model (dotted line). Right: mean velocity profile for the channel flow at $Re = 395$, 590 and 950. Results obtained with DGM/ILES (dots) are assessed with respect to the DNS of Moser *et al.* and Hoyas *et al.* (solid)

flow at $Re_b = 2800$ and 10595 (figure 2).

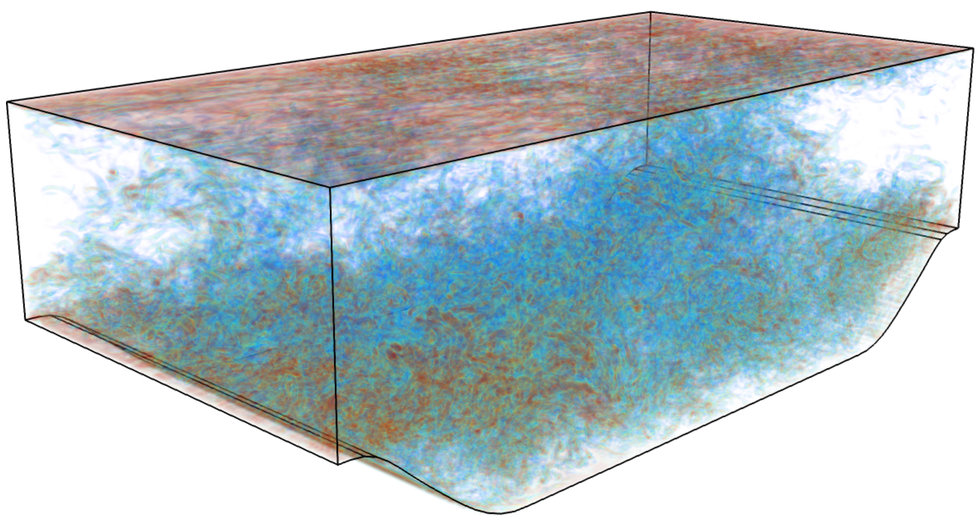

Figure 2: 2D periodic hill at $Re_b = 10595$. Volume rendering of Q-Criterion.

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