The influence of inflow and flow control on the instability and reattachment process of separated flow over a bump

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Laminar boundary layer separation is a ubiquitous phenomenon present in several aeronautical applications, such as low-pressure turbines (LPT) at high-altitude flight and Unmanned Aerial Vehicle (UAV) or Micro Aerial Vehicle (MAV) wings. The separation will eventually have a destructive impact on the aerodynamics and performance, hence, reducing or suppressing the separation by means of flow controls is a clear direction towards more sustainable aerospace technologies. Flow separation is mainly associated with the presence of a local adverse pressure gradient. These phenomena characterize the size and dynamics of the separated flow, which in turn are dominated by the laminar-turbulent transition process [1]. In this contribution, we study the dynamics and instability properties of the separated shear layer in response to different inflow conditions, from laminar with periodic forcing to freestream turbulence and explore flow control strategies.

Direct Numerical Simulations and implicit Large Eddy Simulations are performed with a high-order DGSEM code of a flow over a wall-mounted bump-shaped geometry inside a channel. The bump geometry imitates the pressure gradients with those encountered on the suction side of an LPT blade. The geometry has been intensively investigated, both experimentally and numerically [2] [3]. Flows are decomposed with triple decomposition into coherent and incoherent features by means to eliminate the periodic contribution of inflow and the stochastic shedding of vortices. Three transition processes are identified from periodic inflow at which process similar to the steady inflow where the appearance of Kelvin-Helmholtz (KH) instability is distinct, cases with the transition are dominated by a cluster of vortices, and a combination of both. This can be exploited by means to guide a controlled actuation via periodic suction and blowing at the wall.

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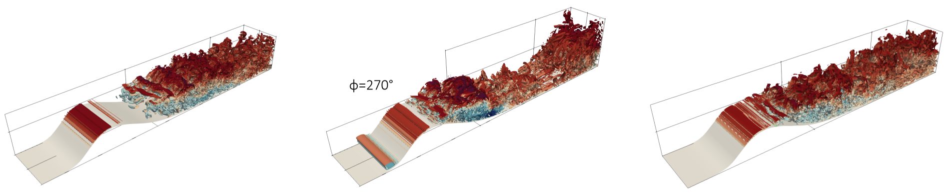

Figure 1: $Q - isosurface$ for steady, periodic inflow, and steady inflow with actuation

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