# Direct Numerical Simulation of Microramp Vortex Generators for Shock Wave/Boundary Layer Interaction Control

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Given the relevance for the aerospace field, shock wave/boundary layer interaction (SBLI) control devices have been the subject of extensive research[1]. Among them, microvortex generators (MVGs) have shown promise in controlling SBLI, but their precise mechanisms and optimal configuration remain to be fully understood.

In this work, we conduct a set of direct numerical simulations (DNSs) to investigate the effect of a microramp MVG on SBLI. The study considers an oblique shock with shock angle equal to $\phi = 9.5°$ interacting with a turbulent boundary layer on a flat plate at free-stream Mach number equal to $M_\infty = 2.0$ and friction Reynolds number $Re_\tau = 2\,200$. The microramp is placed at a distance $14.2\,\delta$ upstream of the impinging shock wave, where $\delta$ is the boundary layer thickness of the uncontrolled boundary layer, and is simulated by means of the immersed boundary method (IBM). The simulations are carried out by means of our in-house solver STREAmS 2.0[2], which is a finite-difference solver adopting state-of-the-art numerical methods to simulate compressible wall-bounded flows with high-fidelity and modern strategies to exploit the most advanced hybrid CPU-GPU high-performance computing architectures.

Preliminary DNS results of our group of a supersonic turbulent boundary layer at $M_\infty = 2.0$ over a microramp (Fig. 1) show that MVGs are able to energise the incoming boundary layer and increase the momentum of the flow close to the wall in a non-uniform way in the spanwise direction, which will have a major impact on SBLI. For example, experimental measurements[3] already observed that this spanwise modulation delays separation behind the device but at the same time worsens it at the sides. Furthermore, thanks to the exceptional computational efficiency of the code, we will be able to carry out sufficiently long simulations with DNS fidelity, which will allow us to gather unprecedented information about the effect of MVGs on the low-frequency unsteadiness typically observed in SBLIs.

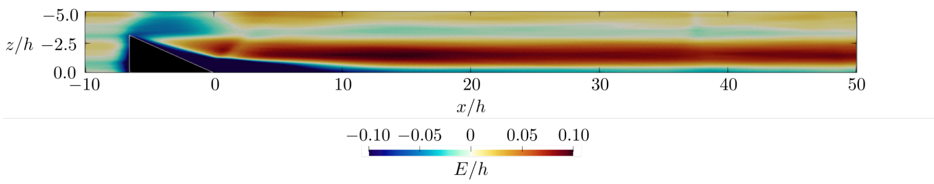


Figure 1: Added momentum $E = \int_0^{0.43\,\delta} (u^2 - u_{BL}^2)/U_\infty^2 \mathrm{d}y$ in the wall-normal plane. $u$ and $u_{BL}$ are the streamwise velocities of the controlled and uncontrolled boundary layers, $h$ is the height of the microramp, $x$ and $z$ are the streamwise and spanwise directions.

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