2021 Virtual HBCU-UP/CREST PI-PD Meeting

Numerical Study of Flow Control of Shock Wave Boundary Layer Interaction in High-speed Flows

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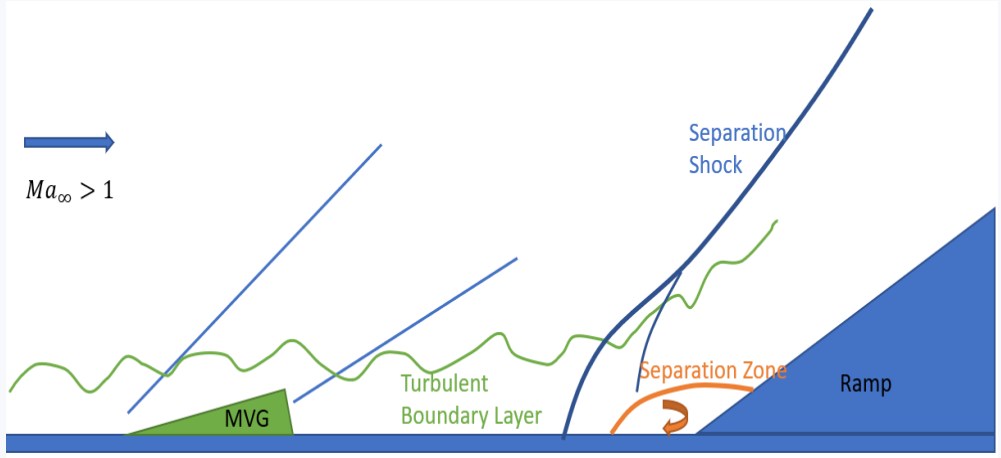
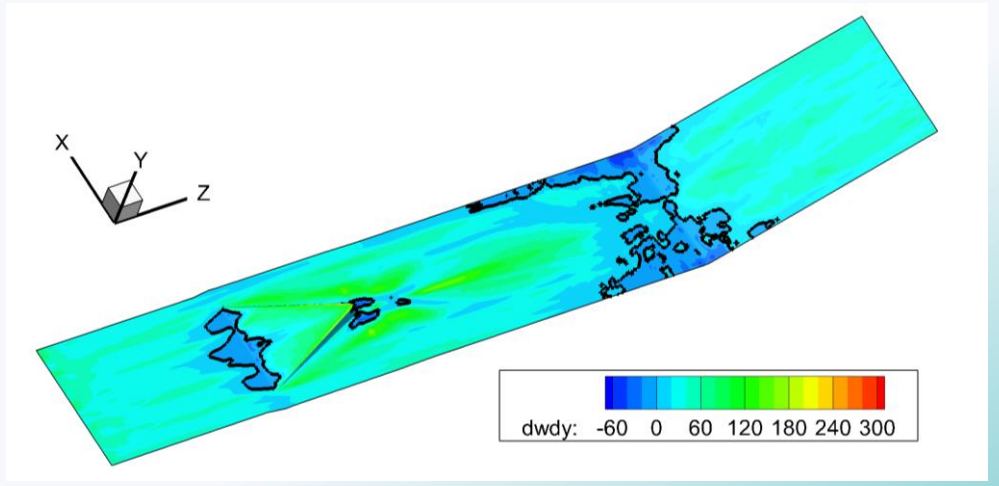
This project is supported by the National Science Foundation grant # **1912191**.
All findings and opinions are those of the authors, not necessarily of the funding agency or AAAS.

Project Overview

- A high-resolution LES (large eddy simulation) is used to study the SWBLI (shock wave boundary layer interaction) in MVG (Micro Vortex generator) controlled supersonic turbulent flows.
- MVG is a kind of low-profile passive control device, which has practical value in engineering, used to control the boundary layer flow.
- The objective of this project is to study the influence of different streamwise positions of MVG on the SWBLI in the supersonic ramp flow.

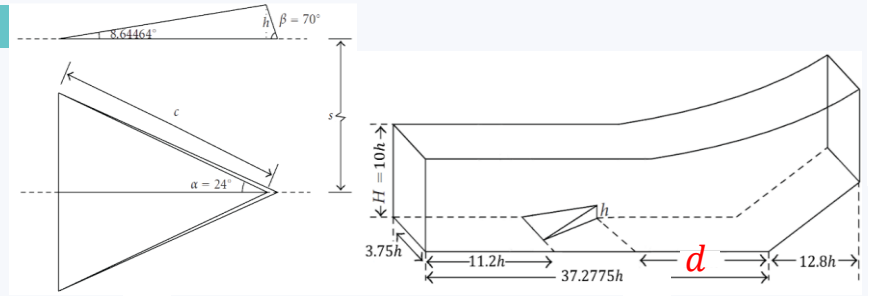


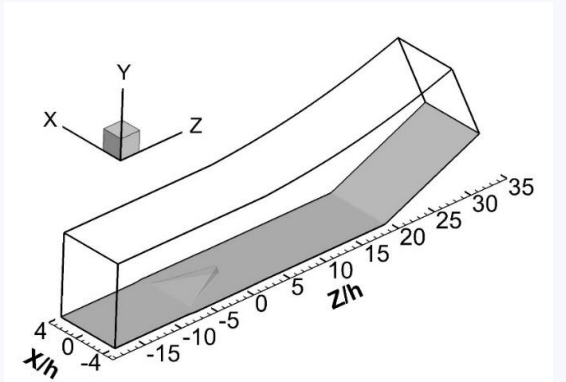


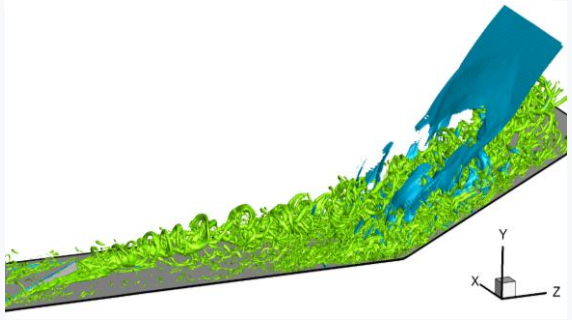
Numerical Methods

Numerical Case Setup

$nspanwise \times nnormal \times nstreamwise$
$= 137 \times 192 \times 1600$



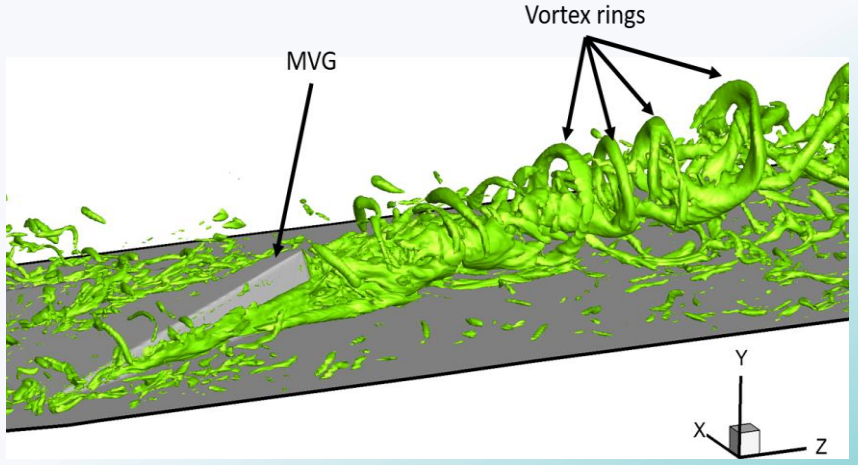




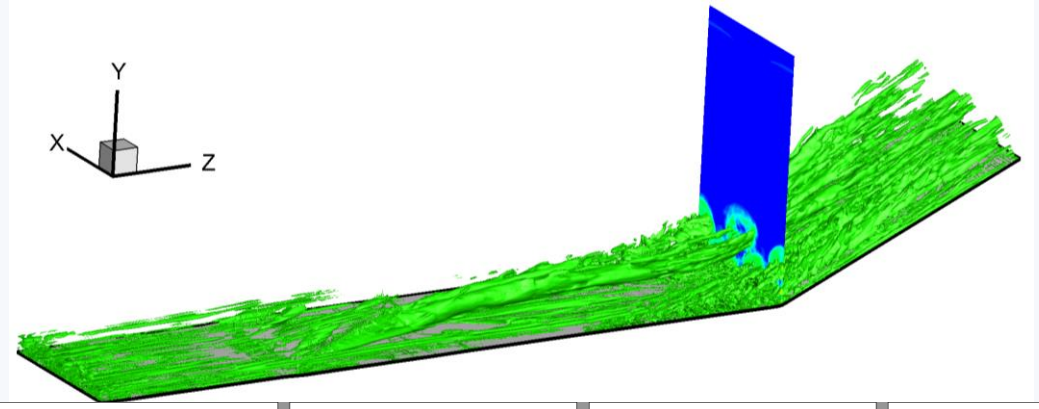
5th order bandwidth-optimized WENO scheme

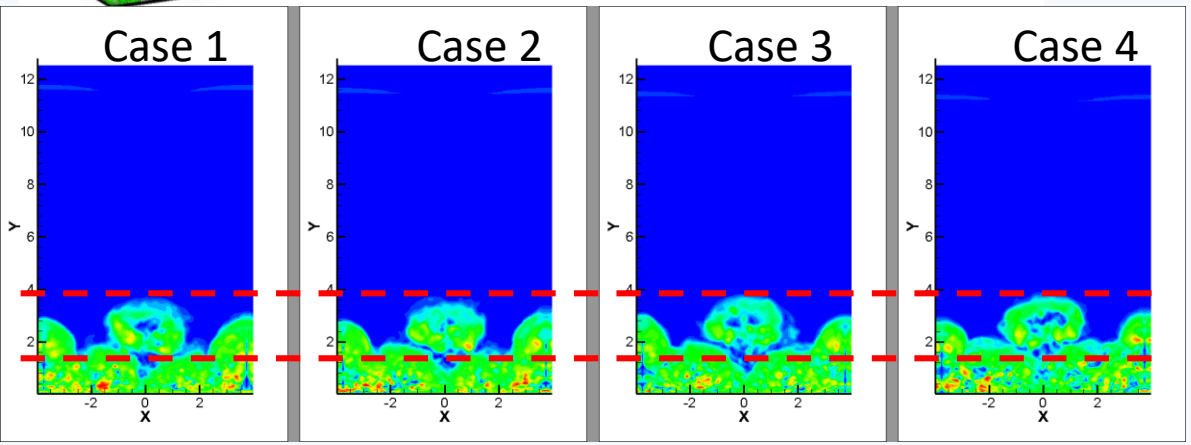
third-order TVD Runge-Kutta scheme in time marching

Case	d	M_∞	Re_θ	T_∞	T_w	h	C	T
1	19.5 h	2.5	5760	288.15 K	300 K	4 mm	340 m/s	1.18×10^{-5} s
2	20.0 h							
3	20.5 h							
4	21.0 h							



Results





- The separation induced by shock wave is reduced significantly in all the 4 cases.
- As the distance between MVG and ramp corner increases, the separation region reduction becomes wider and the vortex rings will be lifted. But these changes are not significant.
- By the spectrum analysis on the velocity signal near the wall at the corner, the spectrum magnitude of dominant frequency reduces significantly as the distance increases, but the relation between the dominant frequency and the distance has not found.
- As the distance between MVG and ramp corner has little impact on the separation reduction and location where vortex rings interact with shock waves, we can move the MVG closer to the ramp corner.

Current and Future Research

1. MVG Array Optimization
2. MVG controlled High-Speed Flow with Different Flow Parameters (Ma, Positions…)
3. More Efficient High-Resolution Solver
4. Noval MVG / Passive + Active Control
5. Hypersonic Control (Ma 5-10)