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DNS OF TURBULENT COMPRESSION RAMP FLOW WITH MACH 6

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Direct numerical simulation (DNS) of hypersonic turbulent flow over a 34-degree compression ramp is conducted by using our high-order finite-difference solver[1]. The free-stream Mach number is 6, free-stream Reynolds number is 10000/mm. Transition in the flat-plate region is triggered by blow-and-suction perturbations and the flow become fully developed turbulent flow upstream the corner region. Analysis of turbulent kinetic energy budgets is conducted, and the results shows that the pressure-dilation and dilation-dissipation terms are not obvious in the upstream flat-plate region, but the two terms is not negligible in the corner region, which shows the intrinsic compressibility cannot be neglected in the corner region. The anisotropy of Reynolds stress tensor is analyzed by using Lumly triangle technique also performed, and the results shows that the turbulent flow in the corner region is more anisotropic.

Unsteady motion of shockwaves and separation bubbles are studied by using Fourier analysis and dynamic model decomposition (DMD) method, the results show the existence of low-frequency oscillation near the separation point, and the low-frequency oscillation is closely related to the breathing-like motion of the separation bubble in the corner region.

Figure 1 shows the numerical schlieren, and strong reattach shock and shocklets are shown in this figure. Figure 2 shows the coherent eddies by using the iso-surface of the secondary invariant of velocity gradient tensor (Q), which shows that coherent eddies are enhanced in the corner region.

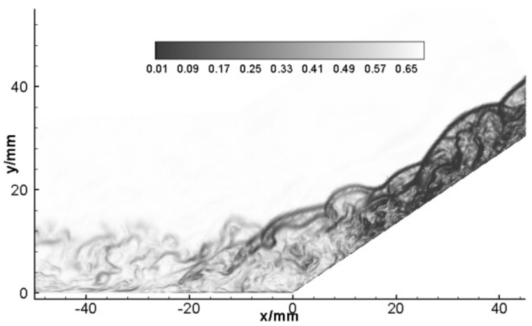

Figure 1 Numerical schlieren (contour of $\|\nabla \rho\|$)

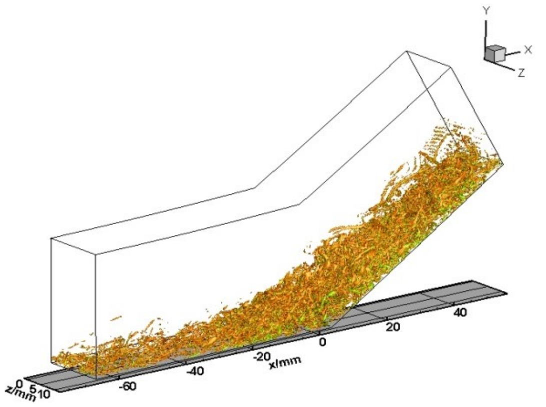

Figure 2 Coherent eddies (iso-surface of Q)

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