Study of High Speed Boundary Layer Transition Induced by Surface Protuberances Using High-Order WCNS Scheme

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Surface protuberances inside a hypersonic boundary layer may lead to premature transition on the vehicle surface. Early transition in turn causes large localized surface heating that could damage the thermal protection system. This paper computationally investigates the unsteady wake development behind an isolated hemispherical bump at three Mach numbers [3.37, 5.26, 8.23]. The corresponding ratio of bump height to boundary layer thickness h/δ is estimated to be about 2.54, 2.08, and 1.19, respectively. A structured mesh, compressible flow solver based on the weighted compact high-order nonlinear scheme (WCNS) is used to perform time-accurate Navier-Stokes calculations. While time-accurate solutions converge to a steady-state for a ratio of 1.19, strong flow unsteadiness is present for a ratio of 2.08 and 2.54. The location of transition is closer to the bump for the highest ratio. Qualitative comparisons between the computation and experiments show good agreement. Particle trajectories illustrate the formation process of the instable shear-layer and the horse-shoe vortices，whose breakdown dominates the transition of the wake flow.

Keywords: Boundary layer transition, Surface protuberances, High-order WCNS scheme, CFD