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Nonlinear growth of unsteady streaks caused by free-stream vorticity in a compressible boundary layer PIERRE RICCO, ELENA MARENSI, University of Sheffield, XUESONG WU, Imperial College London — The nonlinear response of a compressible boundary layer to unsteady free-stream vortical fluctuations is investigated theoretically and numerically. We focus on low-frequency streamwise-elongated perturbations, known as streaks or Klebanoff modes. The nonlinear streak evolution is described through the nonlinear unsteady compressible boundary-region equations. The free-stream flow is studied by including the boundary-layer displacement effect and is matched asymptotically with the boundary-layer flow. The nonlinear interactions inside the boundary layer drive an unsteady two-dimensional flow of acoustic nature in the outer region through the displacement effect. A close analogy with the flow over a thin oscillating airfoil is exploited to find analytical solutions. In the subsonic regime the disturbances propagate in all directions, while at supersonic speeds the fluid ahead of the body is undisturbed and the perturbations are confined within the Mach dihedron. Nonlinearity stabilizes the velocity and temperature streaks. Increasing the Mach number inhibits the kinematic fluctuations but enhances the thermal streaks. An abrupt deviation of the nonlinear solution from the linear one is observed in the case pertaining to a supersonic wind tunnel.

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