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Computations of Crossflow Transition in Supersonic Swept Wing Boundary Layers LIAN DUAN, National Institute of Aerospace, Hampton, VA, MEELAN CHOUDHARI, FEI LI, NASA Langley Research Center, Hampton, VA, MINWEI WU, National Institute of Aerospace, Hampton, VA — A common cause for transition over swept wing configurations of a supersonic aircraft is the crossflow instability of the three-dimensional boundary layer flow. This study seeks to analyze the nonlinear stages of transition due to crossflow instability, with the eventual goals of enabling efficient yet accurate predictive models and, potentially, obtaining clues for better control of the transition process. To achieve these goals, direct numerical simulations are performed to examine the laminar breakdown process in a supersonic swept airfoil boundary layer. Different mechanisms of transition are studied with an emphasis on the breakdown initiated by the high-frequency secondary instability of stationary crossflow modes. The secondary instability is introduced via inflow forcing derived from a two-dimensional, partial-differential-equation based eigenvalue computation. The simulation tracks the linear and nonlinear growth of the secondary instability wave, the resulting onset of laminar-turbulent transition, and the fully turbulent flow downstream. As the secondary instability grows, small rib-like structures develop on top of the tubular structure. These structures are aligned at an oblique angle to the axis of the crossflow vortex, and are similar to the rib-like structures observed in previously reported computations of secondary instability in incompressible flows. Farther downstream, even smaller structures emerge and the laminar breakdown process ensues.

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