Abstract Submitted
for the DFD19 Meeting of
The American Physical Society

On the evolution of the velocity gradient in a minimal simulation unit of transitional boundary layers[1] AHMED ELNAHHAS, PERRY JOHNSON, ADRIAN LOZANO-DURAN, PARVIZ MOIN, Center for Turbulence Research, Stanford University — The transition of a boundary layer from laminar to turbulent state is associated with a rapid increase in friction and heat transfer coefficients and is accompanied by the rapid growth of velocity gradients throughout the boundary layer. This can be appreciated by visualizing isosurfaces of Q-criterion or other vortex identifiers and is particularly evident in late-stage transition when growing structures abruptly break down into more chaotic flow, generating turbulent spots. We consider the evolution of several velocity gradient invariants integrated in cross-stream planes using direct numerical simulations of canonical transition scenarios with minimal spanwise extent. The spanwise domain is restricted to fit only one wavelength of the oblique wave, leading to a single Λ-vortex being present at any streamwise location. The minimal unit simulation displays the main features of transition in larger domains, such as a realistic skin friction coefficient profile. The budget of the squared Frobenius norm of the velocity gradient tensor shows that the pressure term is orders of magnitude smaller compared to the source and sink terms. Furthermore, the profile of the Q-criterion squared exhibits a distinct plateau after the initial emergence of the hairpin vortex, and appears to be a good indicator of the onset of transition.

[1]Supported by NASA and DOE

Ahmed Elnahhas
Center for Turbulence Research, Stanford University

Date submitted: 31 Jul 2019 Electronic form version 1.4