Abstract Submitted
for the DFD17 Meeting of
The American Physical Society

Global modes and transient response of oblique shock/boundary layer interactions at Mach 5.92[1] NATHANIEL HILDEBRAND, ANUBHAV DWIVEDI, JOSEPH W. NICHOLS, GRAHAM V. CANDLER, University of Minnesota - Twin Cities, MIHAILO R. JOVANOVIC, University of Southern California — We apply Direct Numerical Simulation (DNS) and global stability analysis to study transitional hypersonic oblique shock/boundary layer interactions. As the incident shock angle increases, 3D instabilities emerge. At the onset of this instability, the global mode is non-oscillatory and selects a spanwise wavenumber that agrees with DNS. Examination of the critical global mode reveals it to be the result of an interaction between small spanwise corrugations at the base of the incident shock, streamwise vortices inside the separation bubble, and spanwise modulation of the bubble strength. Here centrifugal instability plays no role in the self-sustaining mechanism. We use adjoint methods to show how the critical global mode is triggered by disturbances in the impinging shock and the incoming boundary layer. Furthermore, we quantify sensitivity of the critical eigenvalue to base flow modifications by combining direct and adjoint information. Our sensitivity analysis indicates that streamwise vortices inside the separation bubble are crucial to the 3D instability. Although centrifugal instability does not contribute to the critical global mode, it does amplify streamwise streaks downstream of the separation bubble. We quantify this effect through an optimal transient growth analysis.

[1]We are grateful to the Office of Naval Research for supporting this study through grant number N00014-15-1-2522.

Nathaniel Hildebrand
University of Minnesota - Twin Cities

Date submitted: 01 Aug 2017 Electronic form version 1.4