Abstract Submitted
for the DFD10 Meeting of
The American Physical Society

The centrifugal instability of the boundary layer on a slender rotating cone in a forced free-stream ZAHIR HUSSAIN, STEPHEN GARRETT, University of Leicester, SHARON STEPHEN, University of Birmingham —
The laminar-turbulent transition of flow within the boundary layer over a slender rotating nose cone (for example a spinning missile) can lead to increases in drag, with negative implications for control and targeting. However, continuing developments on spinning projectiles, which have furthered understanding of the onset of laminar-turbulent transition over rotating cones, may lead to design modifications and significant cost savings. Experiments in the literature have shown that increasing the incident free-stream has a stabilizing effect on these spiral vortices. Furthermore, Kobayashi (1981) has calculated the stability diagram for a slender cone of half-angle 15° using the Orr-Sommerfeld approximation. In this study, we provide a new mathematical description of the onset of counter-rotating spiral vortices observed for a 15° rotating cone placed in forced free-streams of varying strength. In particular, we resolve appropriate scalings in order to include variations in the basic-flow profiles, accounting for the influence of streamline curvature. A combined large Reynolds number and large vortex wavenumber analysis is used to obtain the asymptotic branch of neutral stability. Our results capture the effects of the governing centrifugal Görtler instability mechanism, and lead to favorable comparisons with existing numerical neutral stability curve results.

Zahir Hussain

Date submitted: 04 Aug 2010 Electronic form version 1.4