Abstract Submitted
for the DFD17 Meeting of
The American Physical Society

Nonlinear Effects of Surface Roughness on Stationary Crossflow Vortices in Three-Dimensional Boundary Layers ADAM BUTLER, XUESONG WU, Imperial College London — High-Reynolds-number 3D boundary-layer flows are strongly dependent on external disturbances. The behaviour of the stationary crossflow instability, which is typically the dominant instability on swept wings in flight conditions, is heavily influenced by surface roughness. We investigate nonlinear interactions between roughness modes and upper-branch stationary crossflow modes when their critical layers coincide. In particular, we focus on the case when the roughness consists of a single mode with slowly-varying amplitude and chordwise and spanwise wavenumbers that are an integer multiple of the crossflow wavenumbers, $(\alpha_w, \beta_w) = r\,(\alpha, \beta)$. In general, the two modes interact at the cubic order to drive jump conditions across the critical layer and influence both the linear and nonlinear development of the crossflow mode. Importantly, this interaction occurs for small surface roughness: in terms of the Reynolds number R based on the local boundary-layer thickness δ^*, this interaction takes place for surface roughness of height $h^* \sim \delta^* R^{-\frac{1}{2}}$. The nonlinear amplitude equation is derived and solved numerically, and the importance of these results for the downstream development of the flow is discussed.

Adam Butler
Imperial College London

Date submitted: 21 Jul 2017