Receptivity of a Blasius Boundary Layer to Freestream Disturbances

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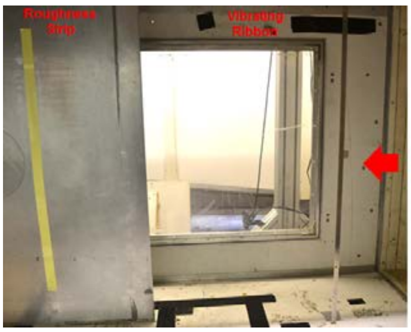
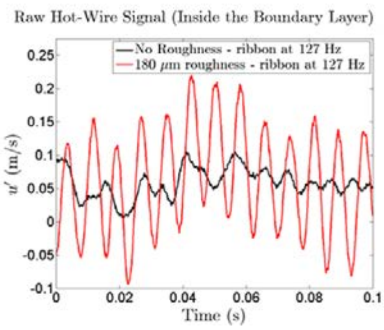
Motivation

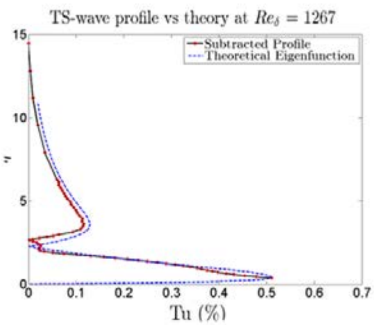
The transition of a boundary layer from a laminar to turbulent state – and the associated increase in skin-friction drag – is of major concern to the aerospace and other industries. In low-turbulence environments, such as in flight, the primary route to transition is predicted to occur - that is the growth of boundary-layer instabilities such as Tollmien-Schlichting waves. Classical linear theory describes the growth of these instabilities well but sheds little light on their initial excitation and the mechanisms by which infinitesimal disturbances can initiate their growth. As such, the receptivity of a boundary layer has been cited as a crucial factor in the transition process and the aim of the current work is to further understanding in this area.

Research

The research contained within this project focuses on the experimental excitation of Tollmien-Schlichting waves on a flat plate via freestream convected disturbances. These disturbances – convected with the freestream velocity – are deemed to represent an idealised model of a single harmonic component of freestream turbulence. Asymptotic theory predicts that no response should be seen within the boundary layer unless roughness is present on the plate. This roughness acts to create a scale conversion mechanism – between the long-wavelength freestream disturbances and the shorter wavelength Tollmien-Schlichting waves – by modulating the boundary layer on a short streamwise scale. The experimental freestream disturbances are created by a vibrating ribbon upstream of the plate and convect past the plate, grazing the boundary layer edge. As predicted disturbances within the boundary layer are only seen with roughness strips present on the plate. The future aim of the current project is to extend this work to three-dimensional roughness elements and to calculate the receptivity coefficients for both the 2D and 3D cases.







Application

With a better understanding of what excites boundary layer modes the possibility to control them *before they begin growing* opens up. Controlling the onset of instabilities through novel methods such as compliant surfaces may become a possibility. And, understanding the scales of roughness important in promoting their growth, will allow better design to avoid them.