Continuous Mode Transition

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Abstract

Some aspects of transition induced by freestream turbulence can be understood in terms of the continuous spectrum of the Orr-Sommerfeld and Squire equations. Instead of discrete mode (Tollmien-Schlichting wave) precursors, transition can be studied, starting from continuous mode precursors. An examination of mode shapes leads to a theory of how freestream disturbances penetrate the boundary layer and, ultimately, provoke transition. Basically, low-frequency modes penetrate the boundary layer, while high frequencies are expelled — a result referred to as shear sheltering. Low frequency penetration can be characterized by a 'coupling coefficient'. This only describes the initial route into the boundary layer. Transition subsequently involves an interaction between low and high frequency modes, to produce breakdown near the top of the boundary layer.

Continuous mode transition is illustrated by numerical simulations of mode interaction. Either one or two modes are prescribed at the inlet to the computational domain. One low frequency mode will generate perturbation jets in the boundary layer. Transition does not occur. One low and one high frequency mode suffice to induce transition.

These studies of mode interactions provide a fundamental perspective on the transition mechanism seen in full simulations with turbulent inflow. DNS of transition induced by grid turbulence and by swept wakes are also reviewed.