Tollmien-Schlichting wave cancellation by Feedback Control

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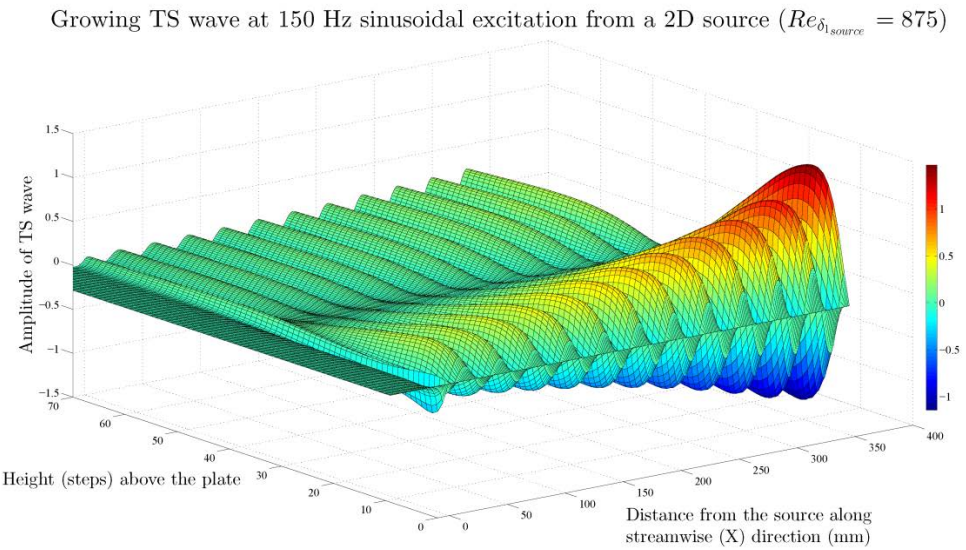
Motivation

Tollmien-Schlichting waves are naturally occurring primary instabilities that enter the boundary-layer because of environmental noise, surface imperfections etc. via the *receptivity* mechanism. Amplification of TS waves is one of the paths to turbulence, which can be delayed by actively interfering with the linear stage of their growth. The picture below shows the calculated streamwise disturbance velocity of a growing TS wave initiated by a two-dimensional source on a flat plate model.

Research

The active control approach in this work uses downstream sensor feedback to upstream actuators to control growing TS waves excited by a speaker on a flat-plate model. The key element of active control is the determination of the transfer functions of the control system connecting the sensors to the source (speaker) and the actuators. The numerical two- and three-dimensional transfer functions are obtained by solving the Orr-Sommerfeld equations These transfer functions are used to obtain the optimal sensor-actuator configurations by calculating the overall degree of control that can be achieved. These configurations are then tested in a wind-tunnel for real-time cancellation.



Application

Transition on current long haul civilian aircrafts is dominated by cross-flow vortices. However, if the sweep of the wing is reduced, or if the cross-flow modes are inhibited, then TS waves become important. Active control of the amplification of spatially unstable TS waves will provide some reduction in skin-friction drag and CO_2 emissions.