Feedback control in spatially growing boundary layers

M. P. Chevalier[*], J. Hœpffner[†], E. Åkervik[†] and D. S. Henningson[†]

Linear feedback control has been applied to transitional boundary layer flows. Information from wall-mounted sensors is used to estimate the flow state. The estimated state is then used to compute the optimal feedback control which is applied as blowing and suction with zero net mass-flux through the wall.

The performance of the combined controller and estimator[1], also known as a compensator, is tested in direct numerical simulations of parallel and spatially growing boundary layers for some typical transition scenarios. The extension to spatial boundary layer flows is an important step toward real applications. In figure 1(a) the wall-normal disturbance velocity is shown in a Falkner–Skan–Cooke boundary layer where traveling cross-flow vortices[2] are triggered upstream in the flow. In figure 1(b) the flow is controlled by means of a compensator where the measurement region is located at $x_m = [40, 150]$ and the control region is located at $x_c = [175, 325]$. For this particular flow exponential disturbance growth is turned into exponential decay over the control area. Downstream of the control area the disturbance starts to grow again due to the inherent instability in the flow.

By applying control to such flows with strong inherent instabilities, through sensors and devices acting only on small parts of the flow, one may achieve dramatic effects by only minute amounts of control energy expenditure. Such control devices can be used in a wide variety of applications, for example, maintaining laminar flow on aircraft wings, relaminarizing/decreasing drag in turbulent flows and enhancing mixing in turbulent flows.

[*]Department of Computational Physics, The Swedish Defence Research Institute (FOI), Stockholm, Sweden

[†]Department of Mechanics, Royal Institute of Technology (KTH), Stockholm, Sweden

[1]Hœpffner et al. *J. Fluid Mech.* **534**, 263 (2005).

[2]Högberg and Henningson *J. Fluid Mech.* **470**, 151 (2002).

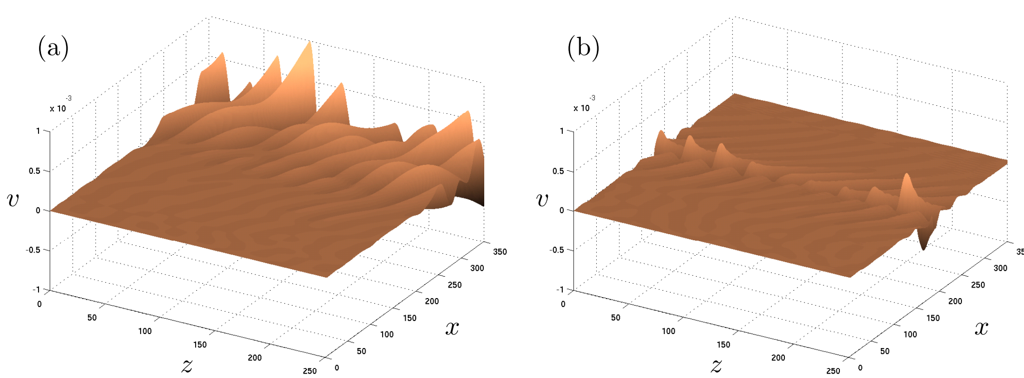

Figure 1: The wall-normal disturbance velocity at $y = 0.5$ for the (a) uncontrolled case and (b) controlled case.