Séminaire PRISME

Real-time Feedback Control for Drag Reduction

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Abstract :

I shall review four ongoing experiments focusing on drag reduction, two involving the control of separation, and two investigating boundary layer transition. All experiments involve an understanding of the dominant physical processes and this insight is used to guide the design of a feedback controller.

In a direct-wake interaction experiment, we use a high-frequency pulsed jet to reduce entrainment of a bluff body wake. In open-loop, the process, although effective, is inefficient : while the base pressure is increased by 33%, the actuation energy consumption is significant so that the net energy saving is more-or-less neutral. The mechanism does not select a specific mode in the unmodified flow. The prospects for feedback control are examined.

In a second experiment, we have used « auxetic » surfaces (negative Poisson's ratio) to control turbulent separation from a curved surface. The auxetic surface is fully retractable and is preferred to static vortex generators. Stall cells appear with sizes that are integer divisions of the chord, depending on Reynolds number and incidence. We show that actuation at a saddle point can be effective in reducing the region of separated flow. Stall cells are shown to have two dominant frequencies, vortex shedding and a wholesale pumping of the cell.

In the remaining two experiments, we use simple feedback control, either to cancel Tollmein-Schlichting waves in a Blasius boundary layer, or to attentuate the transient growth of Klebanoff disturbances in bypass transition. In each experiment, we use simple superposition of disturbances to achieve some cancellation, followed by a simple PI feedback controller to cancel the residue.

TS waves are generated 'naturally' by a receptivity process in which they are excited by an oscillating ribbon above the boundary layer. Interestingly, at large ribbon amplitudes, the growth of TS waves is 'bypassed' and Klebanoff distortions appear. In the last experiment, we also use a turbulence grid to promote bypass transition, in this case F- and Γ-shaped plasma actuators are used.

Three of the experiments are amenable to more sophisticated model-based control. The prospects for future work are discussed. All of these experiments involve collaboration with colleagues at Imperial.