Application for Industry

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Motivation

The main body of my current research is the investigation of the linear stability of the laminar flow over an aerofoil perturbed by a stationary crossflow mode near the leading edge. For a specific distinguished scaling of the spanwise wavenumber, the non-parallel variations of the flow do not appear merely as higher-order corrections as usual, but instead play a leading order role in its stability.

Stationary crossflow vortices have been shown to have a stronger effect on transition in low-turbulence environments than their traveling wave counterparts, and are primarily sensitive to surface roughness. For an instability mode of fixed physical spanwise wavelength, this non-parallel regime occurs close to the leading edge, where the vortices are generated. The receptivity of crossflow modes in this regime will thus have an important effect on their later development.

Research

The dispersion relation for this regime allows neutral modes to occur, providing a second neutral point in conjunction with that in the inviscid regime further down the wing. The non-parallel variations of the base flow and the perturbation are shown to give the same contribution to the instability's growth rate, and provide a stabilising effect across the majority of the regime.

A separate sub-region has been shown to occur where these non-parallel variations dominate, while the pressure takes on a passive role as in a classical boundary layer. For a wing that can be treated as spanwise-infinite, this sub-region is located around the pressure minimum of the base flow. This sub-region is currently being investigated.

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The leading order effects of non-parallelism on the instability's growth means that the usual Orr-Sommerfeld methods cannot be applied to the flow in this region; the chordwise and spanwise variations of the perturbed flow must be taken into account.

Once the investigation of the pressure minimum sub-region is complete, the next step will be to perform a receptivity analysis for this non-parallel regime. This, along with the presence of a neutral point and the stabilising effect of non-parallelism in this regime, suggests that the receptivity mechanism for the crossflow mode here is an important part of the overall development of the instability.