Vortex interactions in separating and reattaching flows

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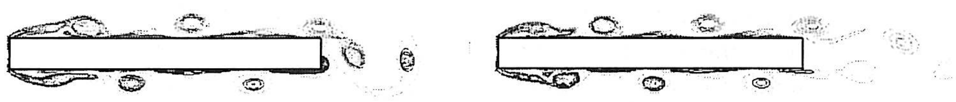
Flows around geometrical shapes as simple as two-dimensional rectangular plates can consist of a display of flow separation, reattachment and vortex dynamics. At the leading edge, there can be shear layer vortices and large-scale structures shed from the separation bubble, which can be modified by acoustic forcing. At the trailing edge, there can be another separation of the flow and shedding of wake vortices. Between the leading and trailing edges, the shed vortices can undergo transition to three-dimensional hairpin structures.

At low Reynolds numbers (less than approx. 1000), a feedback loop consisting of pressure pulses generated by leading edge vortices passing the trailing edge and a receptive leading edge separation shear layer, results in the locking of the vortex shedding frequency. The preferred Strouhal number of the shed vortices proceeds in a staged fashion as a function of plate length, similar to impingement type flows. At higher Reynolds number for unforced flows, the feedback loop disappears as the flow becomes more turbulent. Remarkably, however, even at these higher Reynolds numbers, it is found that peaks in generated sound levels in closed ducts and peaks in base suction for acoustically forced flows follow a similar staging in frequency.

In this presentation, discussion will be focussed on the structures that are present both in the laminar and the turbulent separating flow around rectangular plates, the interaction between structures shed at the leading and trailing edges, the phasing of vortex formation with acoustic forcing, and the role of the vortex structure dynamics in modifying base suction. Insight will be provided by flow visualisation using PIV and detailed numerical predictions using the spectral element method.



Predicted flows at two different forcing frequencies.

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