distinguished speakers series

The Department of Mechanical and Materials Engineering presents:

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Vortex formation and shedding characterized by Lagrangian techniques

We study the formation and shedding of vortices in two vortex-dominated flows in order to detect coherent structures objectively (i.e., in a frame invariant fashion) in massively-separated flow. We employ two specific Lagrangian techniques in this work: the finite-time Lyapunov exponent (FTLE) and the Lagrangian-Averaged Vorticity Deviation (LAVD). The FTLE analysis yields ridges of Lagrangian repulsion and attraction that have been shown to identify transport barriers in a range of flow fields, and vortex boundary features in vortex-dominated flows. The LAVD is a scalar quantity that is the trajectory integral of the normed deviation of the vorticity from its spatial mean. This method can identify the set of fluid that is interior to a rotating, materially-coherent vortex over an entire integration time. In recent work, we have shown that using FTLE to identify and track material points associated with forming and shedding vortices can indicate a shedding time that correlates well to surface pressure and body force extrema on a stationary circular cylinder in cross-flow and dynamic stall on a 2D flat plate undergoing a 45^{o} pitch-up maneuver. The LAVD method has been used specifically to define a materially coherent area in which to calculate circulation of forming leading edge vortices on the same 45^{o} pitch-up plate maneuver. Using this method, we calculate circulation on the same set of fluid particles that become the coherent vortex, but starting at early times as that fluid travels over the plate leading edge and acquires vorticity. When done in this way, the circulation peak timing matches well with peak lift and there is relatively little subjectivity involved in the implementation of the analysis.

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