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Lagrangian Coherent Structures and the Kinematic Theory of Unsteady Separation

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The problem of determining where unsteady fluid flow separates from a no-slip boundary is long-standing and challenging. Despite some landmark advances, a practical criterion remains elusive. Recent theoretical developments in Lagrangian Coherent Structures, however, have a suggested a new approach to the problem. We review these ideas, and present the results of a combined experimental and numerical study of unsteady flow separation for a canonical flow geometry. Experimentally-detected material spikes are directly compared to separation profiles predicted from numerical shear-stress and pressure data. For steady, periodic, quasi-periodic and random forcing, fixed separation is observed, and experimental observations and theoretical predictions are in close agreement. The transition from fixed to moving separation is also reported, and methods for dealing with this scenario are discussed. In collaboration with Matthew Weldon, Gustaff Jacobs, San Diego State University; and George Haller, Morgan Stanley.