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Modeling the transient response to momentum injection for flow over an airfoil in deep stall using data-driven and projection-based methods[1] KATHERINE ASZTALOS, SCOTT DAWSON, DAVID WILLIAMS, Illinois Institute of Technology — Direct numerical simulations are performed for leading-edge momentum injection control of flow over a NACA0009 airfoil at post-stall angles of attack. We consider cases where the wake is both stable (Re = 200) and unstable (Re = 500), and find that the flow response is comparable in both regimes, though with some sensitivity to the instantaneous flow state in the unstable case. We investigate the physical mechanisms governing the interactions between the disturbance and the natural flow state using both dynamic mode decomposition (which is an entirely data-driven approach), and Galerkin projection of the governing Navier-Stokes equations onto a subspace obtained from proper orthogonal decomposition. In particular, we show that projecting a linearized Galerkin projection model can accurately predict DMD modes, giving an understanding of the origin of these modes from the underlying governing equations. More generally, this also suggests a method for approximating DMD modes from non-time-resolved data. We assess the ability of the resulting models to predict the time-evolution of the flow state of the actuated system. We also study the ability of our models to capture the finite-time-horizon energy growth present in the full system.

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