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Modeling unsteady forces and pressures on a rapidly pitching airfoil[1] NICOLE K. SCHIAVONE, SCOTT T.M. DAWSON, CLARENCE W. ROWLEY, Princeton University, DAVID R. WILLIAMS, Illinois Institute of Technology — This work develops models to quantify and understand the unsteady aerodynamic forces arising from rapid pitching motion of a NACA0012 airfoil at a Reynolds number of 50 000. The system identification procedure applies a generalized DMD-type algorithm to time-resolved wind tunnel measurements of the lift and drag forces, as well as the pressure at six locations on the suction surface of the airfoil. Models are identified for 5-degree pitch-up and pitch-down maneuvers within the overall range of 0–20 degrees. The identified models can accurately capture the effects of flow separation and leading-edge vortex formation and convection. We demonstrate that switching between different linear models can give accurate prediction of the nonlinear behavior that is present in high-amplitude maneuvers. The models are accurate for a wide-range of motions, including pitch-and-hold, sinusoidal, and pseudo-random pitching maneuvers. Providing the models access to a subset of the measured data channels can allow for improved estimates of the remaining states via the use of a Kalman filter, suggesting that the modeling framework could be useful for aerodynamic control applications.

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