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On the lift and vortices of an asymmetrically pitching foil[1]
SHUJI OTOMO, University of Edinburgh, KAREN MULLENERS, EPFL, KIRAN RAMESH, University of Glasgow, IGNAZIO MARIA VIOLA, University of Edinburgh — Research on unsteady aerodynamics has significantly grown in recent years due to its relevance to bio-inspired flight. We experimentally investigate the influence of kinematics on the unsteady lift force, flow topology, and vortex dynamics on a pitching NACA 0018 foil at a Reynolds number of 3.2×10^4. We consider the effects of varying pitching frequency and amplitude, as well as amount of asymmetry in angle-of-attack time history. Time-resolved force measurements and particle image velocimetry are performed. We compare the measured lift force with the linear theory of Theodorsen. This analytical model correctly predicts the general trend of the lift force over a pitching period, even for large-angle-of-attack oscillations and non-sinusoidal kinematics. However, when vortical flow structures separate from the foil, the theory overpredicts the lift force. In these conditions, the difference between the linear theory and the measured lift is accounted by a simple model based on the impulse method. Our findings will contribute to the understanding of largely separated flow and to the development of low-order models.

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