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Unsteady vortex dynamics for finite-aspect-ratio pitching wings¹ RYAN JANTZEN, KUNIHIKO TAIRA, Florida State University, KENNETH GRANLUND, MICHAEL OL, U.S. Air Force Research Laboratory — We examine the vortex dynamics around low-aspect-ratio pitching wings and the corresponding unsteady aerodynamic loading using direct numerical simulations with the immersed boundary projection method. Finite-aspect-ratio wings of two and four with rectangular planforms are considered to pitch about the leading edge, from an angle of attack of $\alpha = 0$ to 45°, over a range of reduced frequencies for a Reynolds number of 300. These parameters are chosen to uncover the influence of fast and slow wing motion on the formation of the wake vortices. We also study the relationship between the vortex dynamics and the unsteady forces exerted on the pitching wing emphasizing the influence from the leading-edge and tip vortices. Companion water tunnel experiments are performed with fluorescent dye visualization and direct force measurements at a Reynolds number of 20,000, which highlight qualitative similarities between the flow fields despite the large difference in Reynolds numbers. The insights obtained from the numerical and experimental results are used as a foundation for the development of closed-form models to predict aerodynamic forces for wings undergoing large-amplitude maneuvers representative of flapping wing kinematics and wings in gusty operating conditions.

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