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Effect of Phase Difference on the Aperiodic Transition in the Flow-Field of a Pitching-Plunging Foil DIPANJAN MAJUMDAR, Department of Aerospace Engineering, Indian Institute of Technology Madras, Chennai 600036, India, CHANDAN BOSE, Department of Aerospace and Mechanical Engineering, University of Lige, Lige 4000, Belgium, SUNETRA SARKAR, Department of Aerospace Engineering, Indian Institute of Technology Madras, Chennai 600036, India — The present work explores the role of phase-difference on the transitional flow dynamics of a pitching-plunging foil. An extensive parameter space of plunge amplitude (h) and phase offset (ϕ) between pitch-plunge motions is considered keeping the pitch amplitude and non-dimensional flapping frequency constant ($\alpha = 15^o$ & $k = 4$). Numerical simulations are performed at a low Reynolds number ($Re = 300$) using an Immersed Boundary Method based in-house Navier-Stokes solver. The phase offset is found to be a crucial parameter in determining the onset of the aperiodic transition. In the range of $10\pi/8 \leq \phi \leq 14\pi/8$, the flow-field and, therefore, the aerodynamic loads remain periodic even for h values as high as $h = 0.475$. Significant enhancement in thrust generation is also observed in this range of ϕ, at all h values. On the other hand, the flow-field turns aperiodic even at lower h values (quasi-periodic at $h = 0.25$ and chaotic at $h = 0.375$) approximately in the range of $-\pi/8 \leq \phi \leq 9\pi/8$. A novel scaling relation is achieved in terms of the effective angle-of-attack and the Strouhal number (based on the peak-to-peak amplitude of the leading edge), which differentiates the distinct dynamical regimes in the parameter space in a robust manner.

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