

Supplementary Information

Efficient Aquatic Locomotion Using Elastic Propulsors With Hybrid
Actuation

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Movie 1. Elastic plate actuated with hybrid actuation at the maximum propulsion ($\phi = \pi/12$) and the maximum efficiency ($\phi = 4\pi/3$). The plate aspect ratio is $\mathcal{A}_{\mathcal{R}} = 2.5$, the mass ratio is $\chi = 10$, and the Reynolds number is $\text{Re} = 1000$. Surfaces of constant vorticity magnitude are plotted for $\omega\tau = 20$.

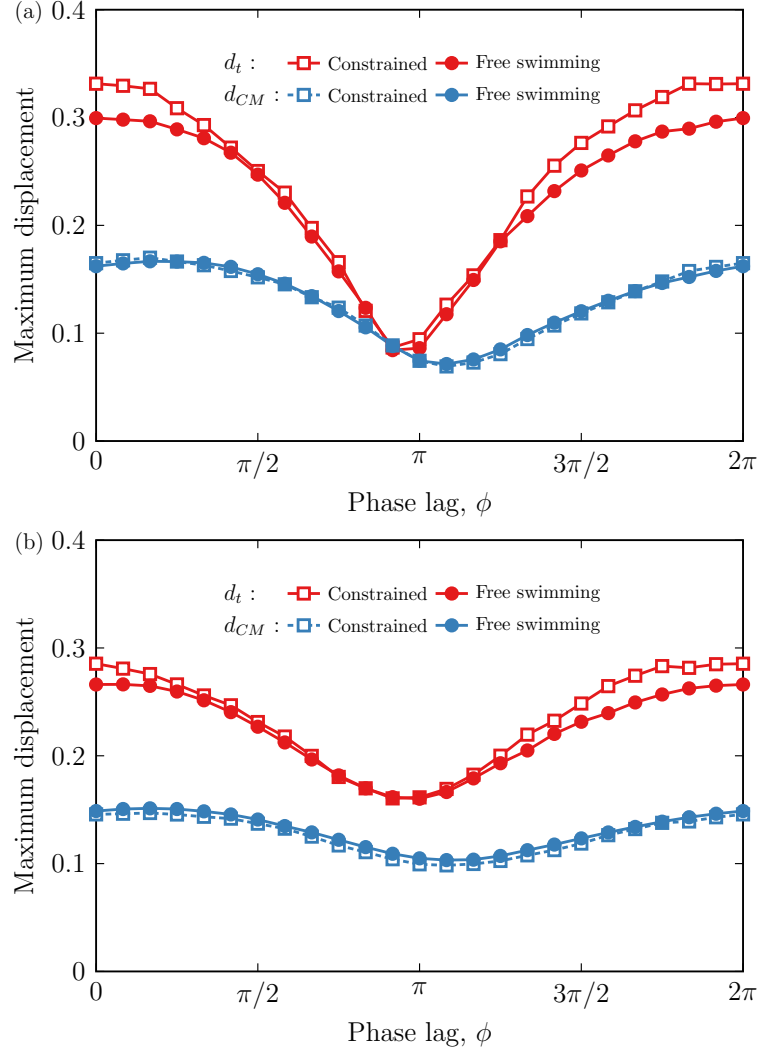


Figure 1: Maximum tip and center of mass displacement as a function of the phase difference ϕ for the constrained combined actuation for (a) $M_0 = 0.1$ and (b) $M_0 = 0.05$. The solid lines show the tip displacement while the dashed lines show the center of mass displacement.

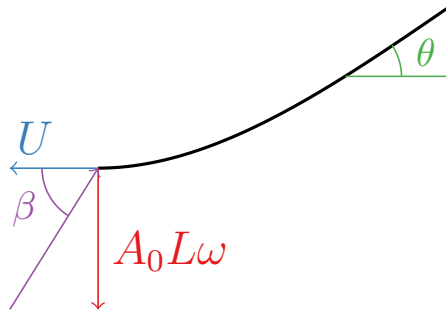
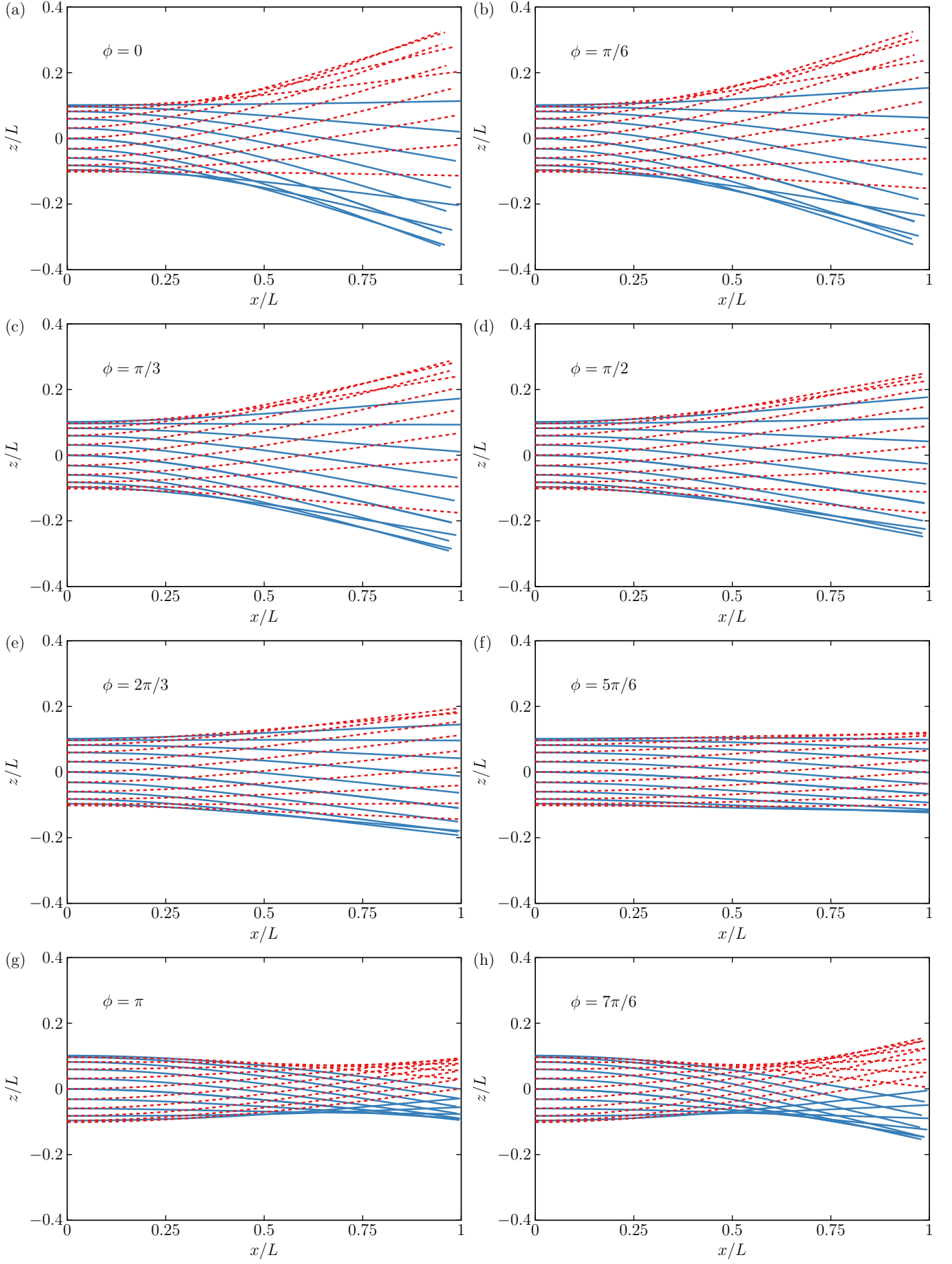


Figure 2: Schematics of the angle ratio θ/β .



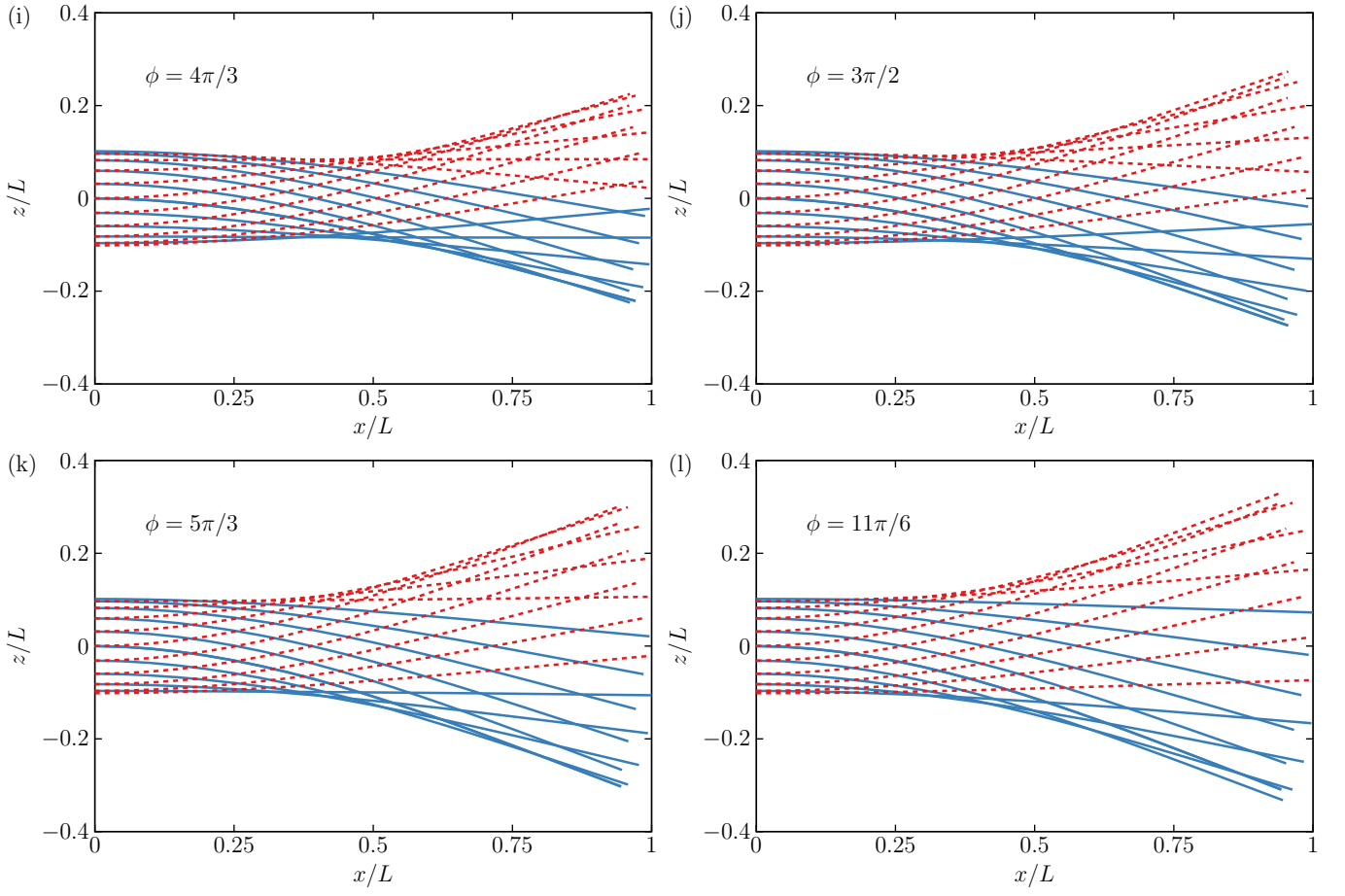


Figure 3: Bending pattern of a plate with combined actuation for (a-l) $0 < \phi < 11\pi/6$ with increments of $\pi/6$. Solid blue lines and dashed red lines correspond respectively to the upstroke and downstroke.

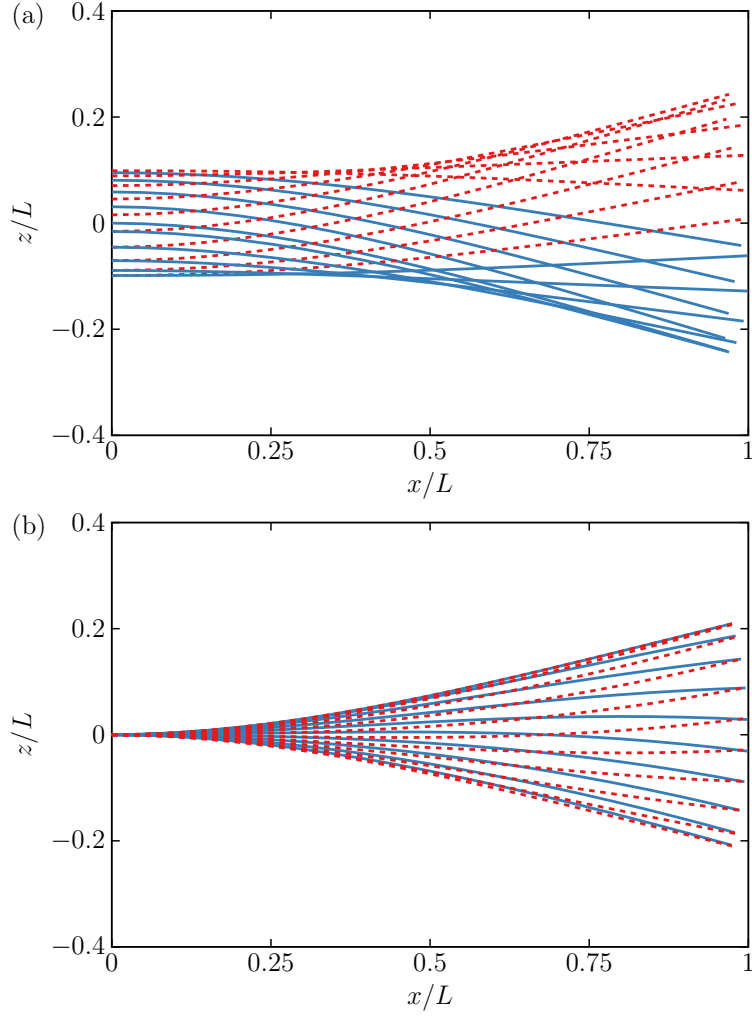


Figure 4: Bending pattern of an (a) externally ($A_0 = 0.1$) and (b) internally ($M_0 = 0.1$) actuated plate. Solid blue lines and dashed red lines correspond respectively to the upstroke and downstroke.

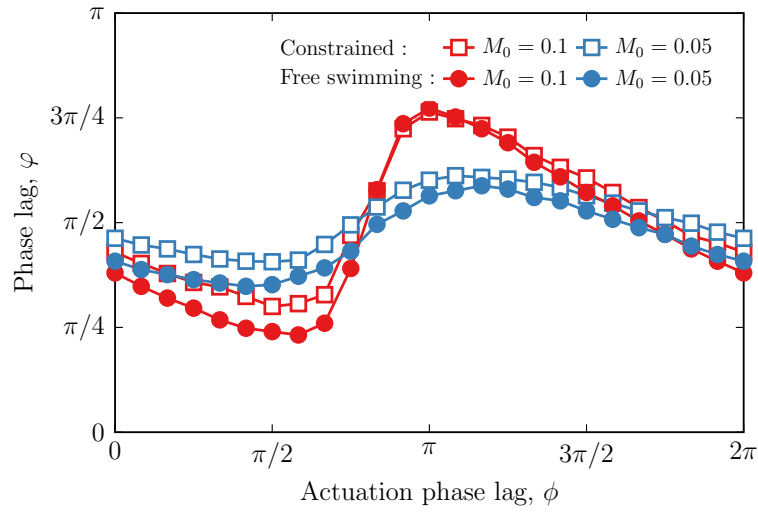


Figure 5: Phase lag between the tip deflection and actuation signal $A(t)$ as a function of the phase difference ϕ .