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FLOW-FIELD TRANSITION IN THE WAKE OF A FLEXIBLE FOIL AT LOW REYNOLDS NUMBER

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Natural swimmers, including various biological species ranging from micro-organisms to large fishes, use flexible ciliary or flapping appendages to propel themselves and perform the different kinds of maneuvers. In this study, we perform numerical simulations of a flexible flapping filament inside free-stream flow using a discrete forcing immersed boundary method (IBM)-based in-house fluid-structure interaction (FSI) solver at a low Reynolds number of 300. An interesting flow-field transition is observed as the bending rigidity (γ) is changed at fixed dynamic heave velocity $\kappa h = 2.3$ ($\kappa = 2\pi f L/U_\infty$ is the reduced frequency and h is the the heave amplitude). At $\gamma = 1.0$, the primary vortex street is deflected downward with secondary vortices being shed and subsequently merged in the far-wake (see Fig. 1(a)). With the decrease in γ to 0.65, the vortex street gets deflected upward after a sustained transient near-field interactions. However, at this γ, the secondary vortices do not exhibit vortex-merging; see Fig. 1(b). In contrast to the previous observations, a bifurcated wake is formed at $\gamma = 0.5$, giving rise to two symmetric vortex streets; see Fig. 1(c). Similar bifurcated wake was also observed by Buchholz and Smits [1] for a low aspect ratio pitching plate. Mechanisms underlying such dynamics will be presented, providing insights on the design of bio-inspired underwater vehicles.

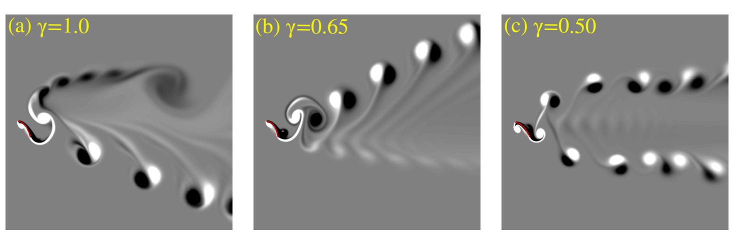

Figure 1: Evolution of flow-field with change in bending rigidity of a flexible foil ($\kappa h = 2.3$ and $t/T = 50.0$).

REFERENCES

[1] J.H.J. Buchholz and A.J. Smitz, On the evolution of the wake structure produced by a low-aspect-ratio pitching panel. *J. Fluid Mech.*, Vol. **546**, pp. 433–443, 2006.