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Mathematical modeling of flipping flaps and flinging fins in fluids[1]

JEFF ELDREDGE, Univ of California - Los Angeles, XUANHONG AN, Illinois Institute of Technology, DARWIN DARAKANANDA, Univ of California - Los Angeles — Inviscid vortex models have served for decades as tools for distilling the physics of lifting and propulsive systems. In large-amplitude motions or massively separated flows, they lose some of their appeal due to the large number of vortex elements required to capture such flows with reasonable fidelity. However, in recent work (and in another talk at this conference by Darakananda et al.), we have shown that computational economy and physical fidelity can both be retained in a vortex model by using a heterogeneous set of vortex elements: vortex sheets of limited extent to capture the early formation of a new vortex structure, and a set of discrete vortices that represent developing and full-formed coherent structures. In this talk, we focus on the use of this hybrid vortex model for predicting interactions with flexible structures. By utilizing structures composed from linked rigid bodies, we can readily distinguish local added mass and vortex contributions along the body. We will demonstrate the overall model on two problems: the self-propulsion of a flexible plate due to rapid rotation about a pivot at the leading edge, and the enhancement of lift by the controlled pivot of a trailing-edge flap. We also discuss the use of such a model as a component in a dynamical observer.

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Jeff Eldredge
Univ of California - Los Angeles

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