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Underlying principles of flexible bio-inspired propulsion: Hydrodynamic wake resonance analysis KEITH MOORED, PETER DEWEY, ALEXANDER SMITS, Princeton University, HOSSEIN HAJ-HARIRI, University of Virginia — Experiments on flexible pitching panels have demonstrated that flexibility can be utilized to double both thrust production and propulsive efficiency. Yet, the exact mechanisms that lead to efficient locomotion with flexible propulsors are not understood. Using experimental particle image velocimetry data from flexible pitching panels, a linear stability analysis is performed and compared with efficiency data. It is shown that when the driving frequency of motion matches a wake resonant frequency a peak in efficiency occurs not just for rigid panels but also for flexible panels, and that the panel flexibility that leads to global optimally efficient locomotion is the one where a structural resonant frequency is tuned to a wake resonant frequency. The primary mechanism to achieve efficient locomotion is to tune the frequency of motion to a wake resonant frequency, while the secondary mechanism is to tune a structural resonant frequency to a wake resonant frequency. The untuned flexible panels exhibit at most a 46% increase in efficiency over the rigid panel, while the tuned flexible panels attain global optimally efficient locomotion with a 100 to 108% increase in efficiency.

Keith Moored
Princeton University

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