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Data-driven, low-order modeling of interflagella synchronization[1]
JONATHAN H. TU, MURAT ARCAK, MICHEL M. MAHARBIZ, Univ of California - Berkeley — Synchrony is a common feature in the locomotive strategies employed by microswimmers. At the level of individual organisms, it can manifest as flagellar bundling or metachronal coordination of cilia. In large populations of microswimmers, interorganism coordination can result in collective behavior. This study focuses on the hydrodynamic interactions between two nearby flagella, looking to develop low-order models that accurately capture the dynamics of flagellar synchronization. Rather than build up a model based on simplified geometries and asymptotic expansions, we take a data-driven, top-down approach. For a single, isolated flagellum, our low-order model exactly reproduces the dynamics of a high-fidelity simulation of the full equations of motion. To extend the model to two flagella, we use insight gleaned from high-fidelity simulations, along with symmetry arguments, to eliminate terms in the equations of motion that are unrelated to synchronization effects. The resulting model accurately predicts synchronization rates at a greatly reduced computational cost. In future work, we hope to extend this approach to model larger numbers of interacting flagella, for which high-fidelity simulations become impractical.

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