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Direct evidence of flagellar synchronization through hydrodynamic interactions DOUGLAS BRUMLEY, MARCO POLIN, KIRSTY WAN, RAYMOND GOLDSTEIN, DAMTP, University of Cambridge — Eukaryotic cilia and flagella exhibit striking coordination, from the synchronous beating of two flagella in *Chlamydomonas* to the metachronal waves and large-scale flows displayed by carpets of cilia. However, the precise mechanisms responsible for flagellar synchronization remain unclear. We perform a series of experiments involving two individual flagella in a quiescent fluid. Cells are isolated from the colonial alga *Volvox carteri*, held in place at a fixed distance d, and oriented so that their flagellar beating planes coincide. In this fashion, we are able to explicitly assess the role of hydrodynamics in achieving synchronization. For closely separated cells, the flagella are capable of exhibiting a phase-locked state for thousands of beats at a time, despite significant differences in their intrinsic frequencies. For intermediate values of d, synchronous periods are interrupted by brief phase slips, while for $d \gg 1$ the flagellar phase difference drifts almost linearly with time. The coupling strength extracted through analysis of the synchronization statistics exhibits excellent agreement with hydrodynamic predictions. This study unambiguously reveals that flagella coupled only through hydrodynamics are capable of exhibiting robust synchrony.

Douglas Brumley
DAMTP, University of Cambridge

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