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Nonlinear dynamics of flagellar bundling PIETER JANSSEN, MICHAEL GRAHAM, University of Wisconsin - Madison — Flagella are long thin appendages of microscopic organisms used for propulsion in low-Reynolds environments. In many bacterial species, helical-shaped flagella driven by a molecular motor will bundle up. This bundling process is poorly understood, and the exact roles of hydrodynamic interactions, helix elasticity, and mechanical contact are unclear. To investigate the bundling, we consider two flexible helices next to each other, as well as several flagella attached to a spherical body. Each helix is modeled as several prolate spheroids connected by springs. For HI, we consider the flagella to made up of point forces, while the finite size of the body is incorporated via Faxén's laws. Before flagella can bundle, they must synchronize. Synchronization occurs fast relative to the bundling process. For flagella next to each other, the initial stage of bundling is governed by rotlet interactions generated by the rotating helices. At longer times, once bundling has occurred, we find that a sharp distinction can be made between "tight" and "loose" bundles, indicated by the local distance between the flagella. As function of the anchor point distance, a sharp transition from tight to loose is found when starting from the completely unbundled state. Incremental steps from stationary situations give multiple stationary for a single anchor distance. We show that the balance between elasticity and strong non-linear hydrodynamic interactions is responsible for this bifurcation behavior.

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