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Propulsion of microorganisms by a helical flagellum BRUCE RODENBORN, CHIH-HUNG CHEN, HARRY L. SWINNEY, H.P. ZHANG[1], University of Texas at Austin — Many microorganisms are propelled by rotating helical flagella. We examine this propulsion in laboratory measurements on macroscopic rotating helices (typical diameter, 12 mm) in a fluid with viscosity 10^5 times that of water; thus the Reynolds number in the experiments is much less than unity, just as for bacteria. We directly measure the propulsive force and torque generated by a rotating flagellum, and the drag force on a translating flagellum, i.e. elements of the propulsion matrices. Our results differ significantly from the predictions of Lighthill's Resistive Force Theory (1975), which treats each segment as an independent slender rod and neglects hydrodynamic interactions between segments of the flagellum. The difference between our measurements and Resistive Force Theory is especially large for helices with small pitch/diameter ratios, which is the regime of many bacteria. We also compute force, torque and drag using the regularized Stokelets method of Cortez et al. (2005). Our numerical results from the regularized Stokelets method are in excellent agreement with the laboratory measurements for helices with parameters (pitch/diameter and length/pitch) in the biologically relevant regime.

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