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Propulsion of microorganisms by a helical flagellum CHIH-HUNG CHEN, BRUCE RODENBORN, HARRY SWINNEY, Department of Physics and Center for Nonlinear Dynamics, University of Texas at Austin, BIN LIU, School of Engineering, Brown University, Providence Rhode Island, HEPENG ZHANG, Department of Physics and Institute of Natural Sciences, Shanghai Jiao Tong University — Many bacteria (e.g. *E. coli* and *Salmonella*) swim by rotating rigid helical flagella, which are typically several μm long and 0.4 μm in diameter. We investigate 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 measure the propulsive force and torque generated by a rotating flagellum, and the drag force on a translating flagellum; thus we can determine all elements of the propulsion matrices along the axial direction. We also compute force, torque and drag using the regularized Stokeslets method of Cortez et al. (2005). Our experimental and numerical results are in excellent agreement. However, these results differ significantly from the predictions of resistive force theories developed by Gray and Hancock (1953) and Lighthill (1975). 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.

Chih-Hung Chen
Department of Physics and Center for Nonlinear Dynamics,
University of Texas at Austin

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