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Propulsion and instability of flexible helical flagella NOOR KHOURI, MOHAMMAD JAWED, Massachusetts Institute of Technology, FANG DA, EITAN GRINSPUN, Columbia University, PEDRO REIS, Massachusetts Institute of Technology — We consider a macroscopic analogue model for the locomotion of uni-flagellar bacteria in a viscous fluid. The rescaling from the original micron-scale onto the desktop-scale is made possible by the prominence of geometry in the deformation process. As a model for the flagellum, we fabricate elastomeric filaments with fully customizable geometric and material properties, and rotate them at low Reynolds number conditions in a glycerin bath. Using digital imaging, we analyze the dynamics of the geometrically nonlinear deformed configurations. Our precision experiments are compared against numerical simulations that employ the Discrete Elastic Rods (DER) method, with an emphasis on quantifying the generated propulsive force. A novel mechanical instability is uncovered, whereby the filament buckles above a critical rotation frequency and we quantify its dependence on the physical and control parameters of the system. A scaling analysis allows us to rationalize the underlying physical mechanism and informs the original biological system that motivated the study.

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