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A computational method of optimizing slip velocities of micro-swimmers with arbitrary axisymmetric shapes HANLIANG GUO, HAI ZHU, RUOWEN LIU, University of Michigan, MARC BONNET, POEMS (CNRS, INRIA, ENSTA), SHRAVAN VEERAPANENI, University of Michigan — This presentation discusses a computational approach to determine the optimal slip velocities on any given shape of an axisymmetric micro-swimmer suspended in a viscous fluid. The objective is to maximize the efficiency of the micro-swimmer, or equivalently to minimize the power loss to maintain a target swimming speed. We consider various families of shapes parameterized by the reduced volume and compute their swimming efficiency. In the case of time-independent slip velocities, we show that, owing to the linearity of the Stokes equations governing the fluid motion, this PDE-constrained optimization problem can be reduced to a simpler quadratic optimization problem, which we solve using a high-order accurate boundary integral method. We found that for a given reduced volume, prolate spheroids are the most efficient micro-swimmer shapes. We proposed a shape-based scalar metric that is predictive on whether the optimal swimmer of a given shape is a pusher or puller without the need of performing the optimization. In the case of time-dependent slip velocities, we observe metachronal waves as an effective way to propel the micro-swimmer. Effects of the shapes will also be discussed.

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