Swimming & Self-Propulsion in Complex Fluids

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Many microorganisms move, feed, and reproduce in complex fluids such as soil, intestinal fluid, and human mucus. The material properties (or rheology) of such fluids can strongly affect an organism's motility behavior. A major challenge is to understand the mechanism of propulsion in media that exhibit both solid- and fluid-like behavior, such as viscoelastic fluids. In this talk, we present experiments that explore the swimming behavior of biological organisms and artificial particles in viscoelastic media. The organisms are the nematode *Caenorhabditis elegans* (L~1 mm) and the algae *Chlamydomonas reinhardtii* (L~ 10 μm). Both organisms are model systems in biology due the wealth of genetic data available for them. We find that, for both organisms, fluid elasticity hinders self-propulsion compared to Newtonian fluids due to the build up of elastic stresses in the fluid and enhanced resistance to flow near hyperbolic points for viscoelastic fluids. As fluid elasticity increases, the organisms' propulsion speed decreases. These results are consistent with recent theoretical models for undulating sheets and cylinders. In order to gain further understanding on propulsion in viscoelastic media, we perform experiments with simple reciprocal artificial 'swimmers' (magnetic dumbbell particles) in polymeric and micellar solutions. We find that self-propulsion is possible in viscoelastic media even if the motion is reciprocal.