Swimming & Self-Propulsions in Viscoelastic Fluids: Live and Artificial ‘Swimmers’

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Many microorganisms evolve within complex fluids, and the rheology of such fluids can strongly affect an organism’s swimming behavior. A major challenge is to understand the mechanism of propulsion in media that exhibit both solid- and fluid-like behavior. In this talk, the effects of fluid elasticity on swimming are investigated using the biological model organism *Caenorhabditis elegans* (Fig. 1) and artificial paramagnetic ‘swimmers’. Swimming and self-propulsion behavior are characterized by tracking the nematode’s and artificial ‘swimmer’ motion and measuring the corresponding velocity fields. For the nematode *C. elegans*, we find that fluid elasticity hinders self-propulsion in agreement with recent theoretical predictions. Furthermore, self-propulsion decreases as elastic stresses grow in magnitude in the fluid. This decrease in self-propulsion in viscoelastic fluids is related to the stretching of flexible polymer molecules near hyperbolic points in the flow. For the paramagnetic ‘swimmers’, we find that fluid elasticity can *enable* self-propulsion for polar particles even under reciprocal forcing at vanishingly small Reynolds number (Re→0); self-propulsion is not possible under the same conditions in Newtonian fluids.

Figure 1: (Left) Snapshot of swimming *C. elegans*. (Right) Particle image velocimetry measurement