

Swimming in Complex Fluids: Pullers & Pushers

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Many microorganisms evolve in media that contain (bio)-polymers and/or solids; examples include cervical mucus, intestinal fluid, wet soil, and tissues. These so-called complex fluids often exhibit non-Newtonian rheological behavior such as shear-thinning viscosity and elasticity. In this talk, I will discuss recent experiments on the effects of fluid elasticity on the swimming behavior of microorganisms. Two main microorganisms are used, the green algae *C. reinhardtii* (a puller-type swimmer) and the bacterium *E. coli* (a pusher-type swimmer). For the case of pullers (*C. reinhardtii*), we find that fluid elasticity hinders the cell's overall swimming speed but leads to an increase in the cell's flagellum beating frequency. The beating kinematics and flagellum waveforms are also significantly modified by fluid elasticity. For the case of pushers (*E. coli*), the presence of even small amount of polymers in the medium suppresses the bacteria run-and-tumble mechanism. The bacteria spend more time in ballistic mode and swim faster as well. Single molecule experiments using fluorescently labeled DNA show that the flow fields generated by *E. coli* are able to stretch initially coiled polymer molecules and thus induce elastic stresses in fluid. These results demonstrate the intimate link between swimming kinematics and fluid rheology and that one can control the spreading and motility of microorganisms by tuning fluid properties.