LOW REYNOLDS NUMBER LOCOMOTION OF MAGNETICALLY ACTUATED MICRO-SCALE DEVICES IN UNBOUND, DILUTE POLYMER FLUIDS

**Abstract:**

Active matter describes systems that are not at equilibrium resulting in complex or directed movement. In this work we focus on active matter systems at low Reynolds (Re) number in non-Newtonian fluids to explore the physics governing locomotion. This is of great interest to biological scientist as the dynamics of most life contains and exist in non-Newtonian environments known as complex fluids. Here, complex fluids are described and characterized using active rheology techniques, revealing viscoelastic effects which are hypothesized to modify the kinematics of rigid active matter. In well characterized dilute polymer solutions we explore the dynamics of two microscale rigid devices described as self-assembled pseudo-chiral microswimmers and bacterial flagella-based bio-hybrid swimmers, which use uniform rotational magnetic fields to drive the systems out of equilibrium. Pseudo-chiral microswimmers acquire their name due to having at least one symmetrical axis, which were previously thought to impede locomotion at low Re number. However, it was found that these swimmers achieve propulsion due to the non-zero coupling between rotational and translational dynamics. On the other hand, the rotation of chiral helical flagella represents a classical mode of non-reciprocal low Re locomotion, primarily used by bacteria. While the locomotion of both chiral and achiral swimmers are well-understood in Newtonian fluids, unexpected dynamics such as propulsion enhancement are observed in viscoelastic fluids. Many models have been put forward to describe the phenomenon of why some active matter increase or decrease their propulsion in complex fluids. These models rely on making a priori assumptions of microswimmer swimming dynamics and swimmer-environment interactions, leading to models that are specific which cannot be generalized to other complex fluids and microswimmers. Therefore, the goal of this work is to experimentally quantify and report the swimming kinematics of pseudo-chiral and chiral microswimmers in dilute colloidal fluids, allowing the verification of different theoretical models and providing new insight into phenomenological assumptions governing microscale locomotion. For the first time, we experimentally show that the heterogeneous distribution of polymer colloids creates anisotropic drag resulting in flagellar nanoswimmers tripling its velocity.