Abstract

The study of low Reynolds number swimmers, such as spermatozoa, bacteria, algae, *Paramecium, Volvox, Opalina, marine zooplankton* etc., is crucial as they affect many biological phenomena, including reproduction, nutrient uptake, etc. Various natural and artificial swimmers use different propulsion strategies to swim in the fluid. Indeed, many of them swim in a helical path due to the coupling of their translational and rotational motion. In the present study, we have used the chiral squirmer model in the steady and unsteady limits to investigate ciliary propulsion in a helical trajectory. The chiral squirmer model, an extension to the squirmer model, considers both the rotational and translational motion of the swimmer.

In the first part of the thesis, we establish a theoretical description of chemotactic navigation of a steady chiral squirmer under varying strength of the field and adaptation time. Interestingly, the presence of chemical noise changes the behaviour of the chiral squirmer qualitatively and quantitatively. However, collective locomotion in a chemical field is more common in nature. Thus, we extend our work to understand chemotaxis of a pair of chiral squirmers considering both near and far–field hydrodynamic interaction between them. We calculate the flow field and other dynamical parameters of the chiral squirmers using the lubrication theory in the near field limit. The most prominent feature of the helical swimming of a pair of chiral squirmers is the appearance of the bounded motion, which was perceived previously for *Volvox* experimentally. We observe that hydrodynamic interaction increases chemotactic success unless noise destroys the correlation among the chiral squirmers.

In the second part of the thesis, we include the time–dependence in the chiral squirmer model since impulsive motion in nature can be observed in many instances, for example, in a predator–prey system. The presence of unsteady forces gives rise to superhelical trajectories. We then compare our results to the existing literature. We also investigate the chemotaxis of an unsteady chiral squirmer and find that due to the time–dependent rotational motion, the squirmer either successfully reaches the target or revolve the target in a diffusive orbit. We conclude by providing some future scopes on this work.

Keywords: Low–Reynolds–number, Self–propulsion, Chemotaxis, Movement and locomotion, Biological and artificial micro-swimmers, Stochastic Processes.