SEMINAR

SCHOOL OF MATHEMATICS AND STATISTICS

DATE: 20 FEBRUARY 2020

TITLE

Hydrodynamics of Micro-organisms
Real life to microfluidic systems

VENUE | TIME

Seminar Room I
04:30 – 05:30 PM

SPEAKER

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ABSTRACT

Microorganisms follow various strategies to swim in a viscous medium. During the last decade, research on self-propelled systems has seen rapid developments and attracted significant interest from the scientific community. From the modelling perspective, much attention has gone into the description of naturally occurring self-propelling motion of various microorganisms. Theoretical works have concentrated on the active systems of different shapes, their interaction and collective behaviors. Experiments have been performed on these active systems to seek validation of these numerical simulations and theoretical frameworks. Most motile microorganisms swim in viscous fluids by deforming slender appendages called flagella and cilia. In ciliated microorganisms, the synchronous motion of cilia/flagella generates metachonical waves which give rise to a relative slip velocity between the body and the surrounding fluid. The squirmer model, introduced by Lighthill and subsequently developed further by Blake, accounts this active slip velocity and analyzes the propulsion of ciliated protozoans.

On the other hand, the dynamics of self-propelling droplets which closely mimic the locomotion of some Protozoal organism has been an area of interest for the last few decades. Droplets have been used in different microuidic devices involving the generation, transport as well as encapsulation of biological cells. In an attempt to understand the swimming of ciliated microorganisms, this talk briefs our study on low Reynolds number locomotion of a spherical viscous droplet, in an unbounded arbitrary Stokes flow, under the combined influence of an inhomogeneous surfactant (diffusiophoresis) and non-isothermal temperature fields (Marangoni effect). The self-generated gradient of the surfactant concentration and the influence of the external temperature field are respectively mapped as a slip velocity and stress discontinuity across the surface of the droplet. Depending on the directions of the induced slip and stress fields, with respect to the Poiseuille flow, the intermediate competitive behavior will be highlighted by analysing the migration velocity, power dissipation and the swimming pattern of the droplet. We have observed that the external stress inverts both the direction of migration velocity as well as the nature of swimming, i.e., turns a pusher into a puller and vice versa, induced by the active slip of the swimmer. The talk then introduces another model on the locomotion of a rigid slip-stick swimmer where the propulsive slip velocity is concentrated around an annular patch which imitates the distinctive surface activity of the microorganisms. In addition, Navier slip condition at the rigid-fluid interface will be used, which contributes to the hydrodynamic slip or stickiness across the surface. This talk hints how our analysis reveals insights on the choice of active slip and the corresponding influence on the swimming velocity and the other relevant swimming characteristics. The competition between a partially covered swimmer and the standard fully covered squirmer will be discussed. These findings will be helpful to design efficient artificial swimmers in terms of higher mobility and lower power dissipation.