Prof. Mohit Dalwadi

Title

Micro-swimmer motility and natural robustness in pattern formation: the emergence and explanation of non-standard multiscale phenomena

Abstract

In this talk I use applied mathematics to understand emergent multiscale phenomena arising in two fundamental problems in fluids and biology.

In the first part, I discuss an overarching question in developmental biology: how is it that cells are able to decode spatio-temporally varying signals into functionally robust patterns in the presence of confounding effects caused by unpredictable or heterogeneous environments? This is linked to the general idea first explored by Alan Turing in the 1950s. I present a general theory of pattern formation in the presence of spatio-temporal input variations and use multiscale mathematics to show how biological systems can generate non-standard dynamic robustness for 'free' over physiologically relevant timescales. This work also has applications in pattern formation more generally.

In the second part, I investigate how the rapid motion of 3D micro-swimmers affects their emergent trajectories in shear flow. This is an active version of the classic fluid mechanics result of Jeffery's orbits for inert spheroids, first explored by George Jeffery in the 1920s. I show that the rapid short-scale motion exhibited by many micro-swimmers can have a significant effect on longer-scale trajectories, despite the common neglect of this motion in some mathematical models, and how to systematically incorporate this effect into modified versions of Jeffery's original equations.

Prof. Satyajit Pramanik

Title

Dissolution-induced natural convection: A Stefan problem

Abstract

The classical Stefan problem, that is observable in melting, evaporation of droplets, freezing, casting, etc., aims to model the boundary evolution caused by the heat diffusion between the phases of a stationary material. Researcher have extensively studied these problems using analytical and numerical methods, and more recently there is a growing interest in problems involving the moving phase-change materials which have some externally provided motion. In this study, we investigate dissolution of solute in a solvent placed in a horizontal concentric cylinder. Theoretical investigation solves a Stefan problem with phase transition due to natural convective flow. To realize the objective, the governing equation for the concentration distribution, stream function–vorticity form of the Navier-Stokes equation for the flow field, and a Stefan condition for calculating the timescale evolution of the front are coupled together with different parameters. These non-linear equations are solved using a stable and second-order accurate boundary-fitted alternating direction implicit scheme with third-order QUICK upwind difference approximation for convective terms. The numerical scheme is validated initially by applying it to solve a natural convection problem with no phase transition, for which benchmark solutions are available. The validated scheme is then applied to the chosen problem followed by a refinement study to obtain a reliable solution. The obtained results are used to analyse the effect of physical parameters such as the Stefan number, geometric aspect ratio of solute to fluid, the Rayleigh number and the Schmidt number on dissolution rates as well as the flow patterns.

Prof. Moitri Sen

Title

Update soon…

Abstract

Update soon…

Prof. Adimurthi A

Title

Update soon…

Abstract

Update soon…