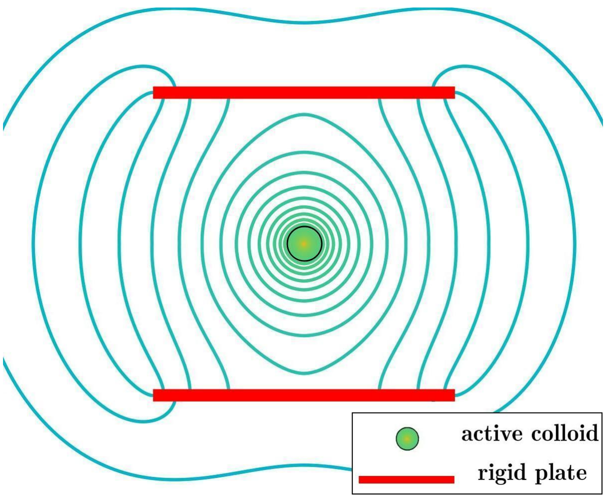
Project title	Phoretic transport near finite interfaces
Principal supervisor	Dr Abdallah Daddi-Moussa-Ider
Second supervisor	Dr Elsen Tjhung
Discipline	Applied mathematics
Research area/keywords	Active matter, phoretic transport, diffusiophoresis
Suitable for	Full time applicants, Part time applicants

Project background and description

Self-propelled active particles, typically encountered in biological systems and synthetic materials, possess the intrinsic capability for autonomous motion within a surrounding fluid medium [1]. These particles exhibit self-sustained locomotion driven by internal energy sources, such as chemical reactions or physical mechanisms, rather than responding to external influences. Examples of active particles include bacteria and engineered microparticles equipped with embedded motors. Active particles exhibit significant promise for future biomedical applications, notably in the context of targeted drug delivery.



Schematic representation of an isotropically active colloidal particle positioned at the central axis in the mid-plane between two coaxially arranged circular rigid plates. Contour lines indicating equal concentration field levels.

Within the domain of active matter research, diffusiophoretic self-propulsion is a well-established mechanism [2]. Self-phoretic swimmers achieve inherent self-propulsion by harnessing localized physico-chemical interactions with their surrounding fluid medium, while adhering naturally to the fundamental constraints of force- and torque-free motion, essential for swimming at the micron scale. While prior theoretical investigations have extensively examined diffusiophoretic swimming near infinitely extended boundaries, limited attention has been given to the physical impact of finite-size effects on the dynamics of active colloids in confined spaces [3]. In numerous biologically and technologically significant applications, accounting for finite-size effects becomes imperative for achieving an accurate and reliable description of phoretic transport mechanisms at the micron scale.

This project aims to elucidate the behavior of active systems in the presence of finite-dimensional interfaces, such as obstacles with finite extents, through the application of far-field analytical theories and comprehensive computer simulations. The project involves formulating various flow problems as mixed boundary value problems, subsequently transformed into systems of dual integral equations on the domain boundaries. The outcomes of this research hold significant potential for practical applications, offering insights into the control and regulation of the motion of self-propelled phoretic active particles in close proximity to aqueous interfaces.

Background reading/references

[1] Bechinger, C., et al. ”Active particles in complex and crowded environments.” Rev. Mod. Phys. 88.4 (2016): 045006.

[2] Golestanian, R. ”Phoretic active matter.” Active matter and nonequilibrium statistical physics, Lecture Notes of the Les Houches Summer School 112 (2019): 230-293.

[3] Daddi-Moussa-Ider, A., Vilfan, A., and Golestanian, R. ”Diffusiophoretic propulsion of an isotropic active colloidal particle near a finite-sized disk embedded in a planar fluid–fluid interface.” J. Fluid Mech. 940 (2022): A12.