School of Mathematics and Statistics
Faculty of Science, Technology, Engineering and Mathematics

2026 PhD Projects

Project title	Collective navigation of micro-swimmers: Principles for optimal targeting in complex environments
Principal supervisor	Dr. Abdallah Daddi-Moussa-Ider
Second supervisor	Dr. Elsen Tjhung
Discipline	Applied mathematics
Research area/keywords	Active matter, microswimmer, hydrodynamics, dual integral equations
Suitable for	Both full-time and part-time applicants

Project background and description

Optimally steering toward a target is crucial across many fields of science and engineering. Examples include guiding airplanes and cruise ships to distant destinations or directing immune cells to defend the organism. Synthetic nano- and microscale autonomous motors offer promising opportunities for biomedical applications, such as targeted biopsies, precision nanosurgery, and directed delivery of radioactive substances to otherwise inaccessible tumours.

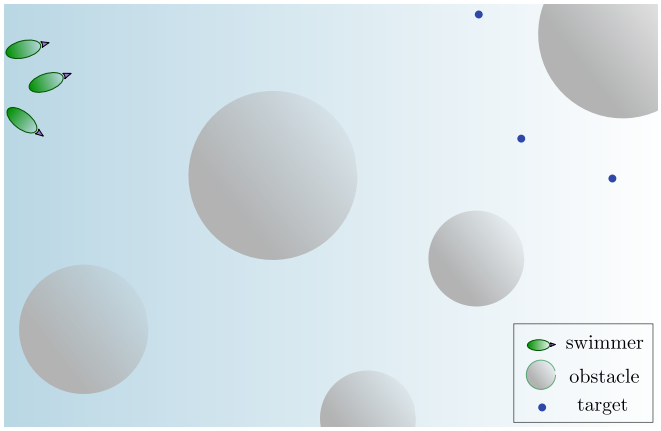

Figure 1: How to optimally steer swimmers to reach given targets with minimal travel time?

Various models were recently developed to explore how an active micro-swimmer can reach a target in minimal time. Yet, the collective locomotion of multiple micro-swimmers, critical for the applications above, remains poorly understood. This raises key questions: What paths should a group of hydrodynamically interacting micro-robots follow to minimize travel time or fuel use? How do nearby boundaries or external flow fields influence optimal strategies? How does the propulsion mechanism affect overall navigation efficiency? Building on previous work, this PhD project aims to advance the understanding of multiple-swimmer navigation at low Reynolds numbers.

This project intends to combine theoretical modelling and numerical simulations to uncover the principles governing collective micro-swimmer navigation. By addressing the open questions above, it will provide guidance for the design of efficient synthetic micro-robotic systems and contribute to our broader understanding of active matter in confined and complex environments. The outcomes are expected to have significant impact both for fundamental fluid mechanics and for emerging biomedical technologies.

Background reading/references

- A. Daddi-Moussa-Ider, H. Löwen, and B. Liebchen, Hydrodynamics can determine the optimal route for microswimmer navigation, *Commun. Phys.* **4**, 15 (2021).