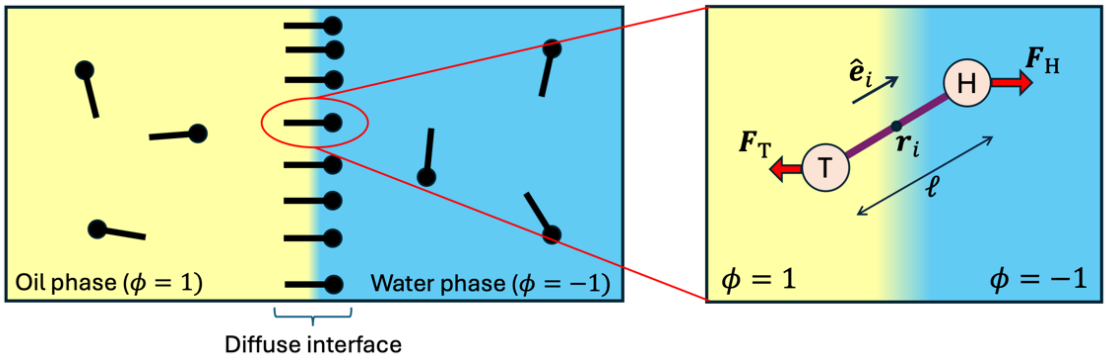
School of Mathematics and Statistics
Faculty of Science, Technology, Engineering and Mathematics

The Open University

2026 PhD Projects

Project title	Bridging microscopic and hydrodynamic theories of anisotropic particles at fluid–fluid interfaces
Principal supervisor	Elsen Tjhung
Second supervisor	Abdallah Daddi-Moussa-Ider
Discipline	Applied mathematics / theoretical physics
Research area/keywords	Statistical physics, stochastic processes, fluid dynamics
Suitable for	Full time applicants, part time applicants

Project background and description
Particles adsorbed at fluid–fluid interfaces play a central role in stabilising emulsions, coating technologies, and designing functional materials. While the behaviour of spherical particles is relatively well understood, that of anisotropic particles—such as rods, ellipsoids, or biological microswimmers like bacteria—remains poorly characterised, particularly when interfacial curvature and hydrodynamic coupling are significant.



The first aim of the project is to generalise the microscopic derivation of the continuum theory developed in Hardy et al. arXiv:2506.12955 to account for a wider range of particle properties, including anisotropic shapes, asymmetric surface interactions, non-uniform capillary attractions, and self-propulsion. This will extend the existing theoretical framework to more realistic scenarios relevant to both synthetic colloids and biological microswimmers.

In the second stage, we will develop complementary microscopic and hydrodynamic simulations to quantitatively compare with the theoretical predictions. The microscopic simulations will resolve particle-scale interactions and torques, while the hydrodynamic simulations will capture long-range flows and interfacial deformation. Together, these approaches will test the validity of the continuum description and provide physical insight into how particle shape, activity, and interfacial hydrodynamics jointly determine the collective dynamics and self-organisation of anisotropic particles.

Background reading/references

- A. J. Hardy, S. Cameron, S. McDonald, A. Daddi-Moussa-Ider, E. Tjhung, Kinetic theory of coupled binary-fluid-surfactant systems, arXiv:2506.12955.
- A. J. Hardy, A. Daddi-Moussa-Ider, E. Tjhung, Hybrid particle-phase field model and renormalized surface tension in dilute suspensions of nanoparticles, *Phys. Rev. E* **110**, 044606 (2024)