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

The Open University

2023 PhD Projects

Project title	Statistical physics of soft condensed matter
Principal supervisor	Dr Elsen Tjhung
Second supervisor	Dr Marc Pradas
Discipline	Applied mathematics
Research area/keywords	Statistical physics, fluid mechanics, soft matter
Suitable for	Full time applicants, Part time applicants

Project background and description

Soft matter includes: liquid crystals in your laptop screen, emulsion in your mayonnaise, and colloidal suspensions in many household products. Although the microscopic details of these matter are quite complicated, *e.g.* they might involve hydrogen-bond, or complex chemical interaction, the macroscopic behaviours of these systems are often very simple. One important result in statistical physics basically says that the macroscopic properties of these system can often be derived from symmetries alone (the same reason the standard model of the universe can be derived from symmetries).

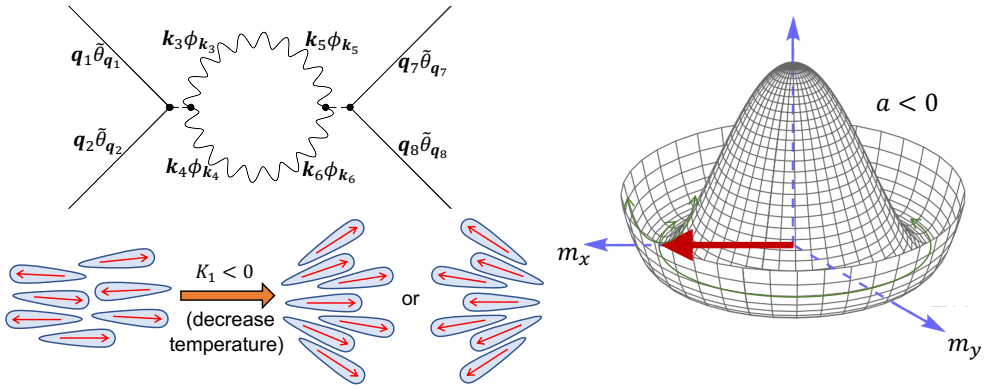

Figure 1: Nematic to splay-bend phase transition in tear-drop-shaped molecules (Ma and Tjhung, *Phys. Rev. E.*, (2019).

In this project we are going to use a variety of computational and analytical tools study the macroscopic behaviour of soft matter. More specifically we might be looking at: the phase behaviour of complex molecules, collective dynamics in living tissues and the effective viscosity of biological soft matter.

Some computational tools we use include computational fluid dynamics (*e.g* lattice Boltzmann and pseudo-spectral method) and molecular dynamics. Students will also be expected to learn and apply new mathematical methods such as solving stochastic differential equations, evaluating path integrals, and using perturbation methods.

Background reading/references

- M. Doi, *Soft Matter Physics*, Oxford Academic, (2013)
- M. E. Cates, E. Fodor, T. Markovich, T. Nardini and E. Tjhung, Stochastic Hydrodynamics of Complex Fluids: Discretisation and Entropy Production, *Entropy*, (2022)
- M. E. Cates and E. Tjhung, Theories of binary fluid mixtures: from phase-separation kinetics to active emulsions, *J. Fluid Mech.*, (2017)
- X. Ma and E. Tjhung, Banana- and pizza-slice-shaped mesogens give a new constrained $O(n)$ ferromagnet universality class, *Phys. Rev. E.*, (2019)