USTC Project - Summer 2014

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Our group uses modelling, simulations and analytic approaches to look problems in soft matter and biophysics. We are particularly interested in mesoscale modelling such as lattice Boltzmann or stochastic rotation dynamics.

Proposed Project: Active nematics

Mixtures of microtubules or actin filaments and motor proteins are model systems for cellular transport. Recent experiments show time-dependent patterns of vorticity in the flow fields created as the motors move along the filaments[1]. Similar 'chaotic' flows are seen for epithelial cell layers and for dense suspensions of swimming bacteria.

One of the main theories to describe the velocity fields is based on a set of continuum differential equations, similar to those for liquid crystals. These lead to the same time-dependent patterns of vorticity and the formation of topological defects which appear to drive the flow[2].

There is evidence that the flows can be stabilised by confinement which is exciting because it would give a way for chemical energy to be converted to mechanical energy. The aim of this project is to try to identify generic features which hold for all the active systems and to extend solutions of the equations to understand flow patterns in confined geometries.

Outcome of the project: To learn about the continuum theories of active systems. Understand the relevant differential equations and the techniques used to solve them. Then to extend the codes to confined systems and to obtain simple solutions which can be compared to experiments. The project would suit students with a background in mathematics or physics who enjoy problem solving and a combination of numerical and analytical work.

[1] T. Sanchez et al, Nature 491, 348 (2012)

[2] S. Thampi, R. Golestanian and J.M. Yeomans, Phys. Rev. Lett. **111** 118101 (2013); EPL (Europhysics Letters) **105** 18001 (2014)