2020 Science Internship on Mathematical modelling of particle transport through asymmetric membranes

Supervisors: Dr Maria Bruna and Dr Ian Griffiths (Mathematical Institute), Geoff Williams (Department of Computer Science).
Start date: 13 October 2014.
Duration: 12 Weeks (full time).
Location of work: Mathematical Institute, Wolfson Centre for Mathematical Biology (WCMB).
Required submission material for candidates: CV, cover letter explaining how you satisfy the selection criteria.
Closing date: 10th October 2014. Informal enquiries can be sent to bruna@maths.ox.ac.uk.

Project details

The transport of proteins and other biological material through constrained geometries is important in many applications, such as kidney dialysis and in the harvesting of proteins for tissue-engineering applications. In all such cases understanding the fundamental transport mechanisms is crucial in order for such technologies to be optimized or upscaled. A key challenge in designing appropriate harvesting or filtration devices is to maximize the capture efficiency while minimizing clogging of the separating device. The latter leads to significant reduction in efficiency and increase in operating costs. Recent experiments conducted by Pall Corporation suggest that membranes that comprise a pore geometry that varies with depth are able to improve separation efficiency. However, the underlying transport mechanisms responsible for the observed improvements are currently not understood since experiments are unable to probe the microscopic behaviour.

This internship will build on models developed independently by Maria Bruna (MB) and Ian Griffiths (IMG) to describe the transport of particulates through spatially varying geometries. The result will be a macroscopic continuum model that captures the complex transport behaviour within such structures, which can be compared with experiments and hence enable optimization through tailored device design. The successful intern will assist in adapting these pre-existing theories and applying the models to this specific problem. A successful internship will provide an opportunity to apply for further funding, while the research also offers an ideal route to working in industry.

We will begin with a discrete description of individual protein transport through a single pore with variable wall geometry that will build on the recent network model developed by IMG (Griffiths *et al., J. Coll. Interf. Sci.*, 432, 2014). We will combine this with recent work by MB that models the transport of particles through a structure composed of fixed spherical obstacles (Bruna & Chapman, *SIAM J. Appl. Math., in preparation*). We will then apply the technique for systematically deriving a continuum description from the discrete model via homogenization as used by MB. The resulting continuum model will be compared with a phenomenological continuum model obtained using the Fick–Jacobs approximation (see, for example, Riefler *et al., J. Phys. Cond. Matter*, 454109, 2010). The predictions of each model will be combined to provide a comprehensive description of the problem, which will enable predictive power for the future design of such filtration and separation devices. Finally, a web-based tool will be developed by Geoff Williams to compare the models, allowing the user to interactively change the membrane structure and observe how the membrane efficiency changes.

Selection Criteria: The candidate should have achieved or be close to completion of a PhD degree in applied mathematics or a similar discipline. Experience in mathematical modelling and scientific computing is essential. Experience in asymptotic analysis and continuum mechanics is desirable.

How to apply
Please apply by email to job07@cs.ox.ac.uk. The deadline for applications to be received is 12 noon on **Friday 10th October 2014**