PhD projects in Fluid Mechanics at The University of Adelaide

Study at The University of Adelaide

The University of Adelaide is one of Australia's leading Group of Eight, research-intensive universities and is consistently ranked among the top 1% of universities in the world. Established in 1874, it is Australia's third oldest university with a strong reputation for preparing educated leaders and delivering research outcomes that contribute to local, national and global wellbeing.

The University is situated on the northern edge of the city of Adelaide, within walking distance of the central shopping precinct. In 2016, and for the fifth year in a row, Adelaide was ranked by the Economist Intelligence Unit's liveablity index as one of the fifth most liveable cities in the world.

Background information.

Two PhD projects are offered with scholarships as part of a wider project *"Mathematics the key to modern glass and polymer fibre technology"*, the ARC Future Fellowship awarded to Associate Professor Yvonne Stokes (February 2017- February 2021). The wider project is concerned with mathematical modelling of microstructured optical fibre (MOF) fabrication for a variety of uses. Mathematics is essential to solving the inverse problem of determining the preform and draw parameters to produce a desired fibre and has already proved to be of significant practical benefit.

Collaboration with members of the world-renowned Institute for Photonics and Advanced Sensing (IPAS) at the University of Adelaide is a key component of this research. IPAS combines scientific and technical excellence with strong industry engagement to facilitate local industry development. Associate Professor Yvonne Stokes is a member of the School of Mathematical Sciences and the Optical Materials and Structures group within IPAS, a vibrant, fast-paced, inclusive research team in glass science and fibre fabrication which provides vital practical knowledge to her research. Similarly, Mathematical Sciences will be the home school of the successful PhD students and they will have the exciting opportunity to become student members of IPAS and have first-hand involvement in experiments conducted within IPAS for validation of their mathematical work. The supervision team for each of the PhD projects will include an experimentalist from IPAS.

Optical fibres are commonly associated with communications networks. But MOFs have revolutionised optical fibre technology, with a virtually limitless range of designs for a wide range of applications. The PhD projects focus on hollow-core tapers or fibres containing a micro-bubble or micro-bottle which are of much current interest as *whispering gallery resonator biochemical sensors* with the limit of detection potentially down to a single molecule.[1,2] They are fabricated from commercially available capillaries

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[1] Tang, T., Wu, X., Liu, L., Lei, X. (2016) Packaged optofluidic microbubble resonators for optical sensing. *Appl. Optics* 55, 395-399.

by first drawing or tapering the capillary down to the required diameter (typically < 100μm), and then heating a small section while, at the same time, pressurising the air inside to form a bottle or bubble in the heated region.[3] The thinner the wall of the micro-bubble/bottle the better the sensor, although some consideration has to be given to its fragility.

PhD 1: Unsteady capillary stretching for microstructured tapers.
This project focuses on mathematical modelling of the fabrication of microstructured tapers used for whispering gallery resonator sensors, mass-spectrometry and medical devices. Their fabrication is by heating and pulling a suitable capillary/preform. Pressurisation of the air channel(s) may be required to achieve the desired geometry. Both flow and temperature sub-models will be required and asymptotic methods exploiting the slenderness of the taper will be used in their derivation. The model will be used to investigate the relationship between the length of the heated region and the temperature, the pulling tension and velocity, the surface tension and pressure, on the length of the taper and the cross-sectional geometry along its length. Experiments will be run, with assistance from skilled technicians, for comparison with the model.

Primary supervisor: Assoc. Prof. Yvonne Stokes, School of Mathematical Sciences, The University of Adelaide.
Co supervisor: Prof. Heike Ebendorff-Heidepriem, Institute for Photonics and Advanced Sensing, The University of Adelaide.

PhD 2: Micro-bubble and micro-bottle blowing in a fibre for whispering gallery resonator sensors.

This PhD project focuses on mathematical modelling of the fabrication of whispering gallery resonator sensors by blowing a micro-bubble or micro-bottle in a heated microstrutured taper. Both flow and temperature sub-models will be required and asymptotic methods exploiting the slenderness and/or the small wall thickness of the taper will be used in their derivation. The model(s) developed will be used to investigate the relationship between surface tension, pressure, wall thickness of the fibre/taper and wall thickness and size of the bubble/bottle. The thinner the wall of the fibre/taper the more sensitive it will be to the applied pressure and the greater the chance of blow-out and, consequently, failure to achieve the desired sensor. Avoiding this, while still achieving thin-walled micro-bubbles/bottles, will be of key interest. The model(s) will be compared with experiments run with assistance from skilled technicians.

Primary supervisor: Assoc. Prof. Yvonne Stokes, School of Mathematical Sciences, The University of Adelaide.
Co supervisor: Dr Yinlan Ruan, Institute for Photonics and Advanced Sensing, The University of Adelaide.

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[2] Zhang, X., Liu, L., Xu, L. (2014) Ultralow sensing limit in optofluidic micro-bottle resonator biosensor by self-referenced differential-mode detection scheme. *App. Phys. Lett.* 104, 033703.
[3] Ward, J.M., Dhasmana, N. Nic Chormaic, S. (2014) Hollow core, whispering gallery resonator sensors. *Eur. Phys. J. Special Topics* 223, 1917-1935.

Eligibility and Enquiries

Applicants should hold or be about to complete an Honours or Masters degree in applied mathematics or a closely related subject area (e.g. physics, engineering) and should have some knowledge of theoretical fluid mechanics. A Class 1 Honours degree, or a Distinction or higher for a Masters degree with a significant research component, are highly desirable. Equivalent international qualifications will be considered.

A candidate of suitable academic merit will receive a studentship comprising full coverage of PhD tuition fees and an annual stipend.

Interested persons should email Associate Professor Yvonne Stokes (yvonne.stokes@adelaide.edu.au), sending

- a covering letter stating your interests and why you are applying,
- your CV,
- your academic record,
- contact details of two referees.