PhD projects in Bubble Acoustics available to international students at Swinburne University of Technology, Melbourne, Australia

Scholarships may be awarded to international students applying for the projects outlined in this file. Details on the scholarships and how to apply are at:

http://www.research.swinburne.edu.au/higher-degrees/application/index.html

Closing date: **31 October 2010.**

International students' applications for scholarships are assessed and ranked centrally by the University, based on the applicant's undergraduate performance and CV relative to all other applicants. There will be a second round closing on **31 May 2011**; however, any projects awarded to applicants in the present round will not be available in 2011.

Address technical or practical queries on the projects and their supervision to Richard Manasseh (rmanasseh@swin.edu.au).

The projects would be based at the Faculty of Engineering & Industrial Sciences at Swinburne's Hawthorn campus.

Students would join a well-established and friendly group spanning two academic institutions (Swinburne UT and the University of Melbourne) and Australia's federal research agency, CSIRO. Depending on the project, existing collaborations with local industries or medical institutes may be used to further support the student with access to equipment and facilities. Students are expected to attend and present at regular informal meetings with other experienced academics, researchers, and students working on related projects.

Melbourne is usually ranked amongst the world's top 10 cities for foreign residents. Swinburne is located in a lively and well-serviced district with many shops, cafés, bars, restaurants and facilities within 5 mins' walk from campus. General information on international student life is at:

http://www.international.swinburne.edu.au/study-in-australia/melbourne/index.html

Sustainable biodiesel production using hydrodynamic cavitation

Supervisor: Richard Manasseh

Algae farms are proposed as one source of biodiesel, yielding a fuel with no net carbon cost. While many algal species produce oil, getting the tiny oil droplets out of the algal cells without a high energy cost is problematic.

http://upload.wikimedia.org/wikipedia/commons/9/9b/Spirogyra_cell.jpg

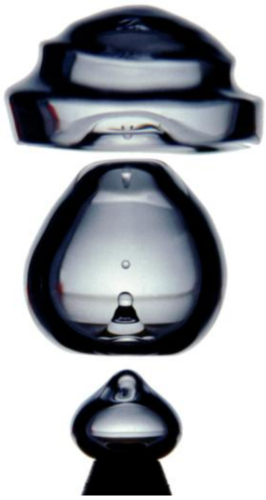
High-power ultrasound improves the extraction of biodiesel by creating bubbles that collapse violently, lysing ("exploding") the algal cells producing the oil. But ultrasound is not energy efficient on a practical industrial scale. Can hydrodynamic cavitation help make the widespread production of biodiesel economic? Hydrodynamic cavitation occurs when liquid flow past an obstruction is fast enough to generate a pressure drop that causes bubbles to form and collapse violently. The microscale mechanics of how this intense process interacts with a biological cell wall is poorly understood. If we can understand exactly how cavitation causes algal cells to release oil droplets, it could lead to more efficient biodiesel production.

Students would undertake precision experiments in which cavitation bubbles are formed in a flow chamber that would be filled with appropriate algal cells. The cells would be imaged microscopically. The aim would be to determine the physical parameters under which the cells release their oil droplets. The project is in collaboration with CSIRO.

Making electrowinning sustainable with acoustic feedback

Supervisor: Richard Manasseh
Co-supervisor: Geoff Brooks

Aluminium production consumes huge quantities of electricity, and tiny changes in the geometry of the electrolytic cells used can result in substantial energy savings. A key issue is the formation of bubbles, blocking electrode gaps and confounding attempts to cut energy costs. Many metallurgical processes also involve the injection of bubbles into molten metals. The bubble formation needs to be monitored somehow, but cannot be observed in the high temperature melt. Can sound be used to provide feedback on the process, enabling engineers to better control it? In this project hydrophones will measure the high- and low-frequency sounds created by gas injection into a model bath. Bubbles will be imaged with high-speed photography.



Manasseh, R, Nicholls, T. 1996, *Album Vis.* **13**, 25-26.

There will be two elements to the work: Firstly, the process of bubble coalescence on an inverted surface modelling an electrode will be studied, focusing on the sound emission. Secondly, experiments on larger, complex volumes of gas injection will develop the signal-processing techniques to extract data on the sizes of the bubbles, which are known to be related to the sound frequencies. Ultrasound may also be applied to image the bubbles. The aim is to develop a correlation between the measured sounds and parameters of practical industrial interest. The project is in collaboration with CSIRO.

Sonoporation for targeted drug delivery (two projects)

Background

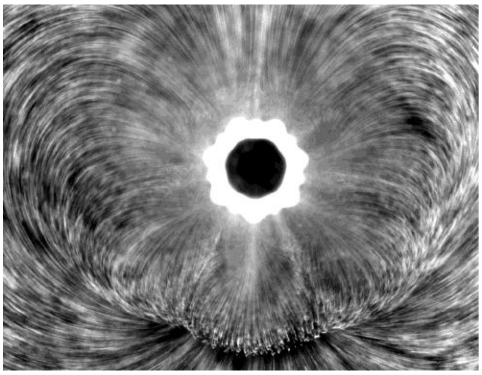
The use of microbubbles for medical therapy is one of the most exciting new trends in microtechnology. Microbubbles are engineered products smaller than a blood cell that are injected intravenously and travel through the body. They resonate in medical ultrasound beams, expanding and contracting with the ultrasonic waves and creating a fluid flow field around them. This is a complex fluid dynamical process. Microbubbles are now been engineered for drug delivery, using a phenomenon called sonoporation. When microbubbles resonate on cell walls, drug or genes the cell normally excludes are found to enter the cell without damaging the cell. This means that drugs against arterial disease or cancer can be included in the microbubble's shell and released only into the diseased cells, delivering very high local doses but very low systemic doses. DNA has also been successfully introduced into cells using microbubble sonoporation, potentially allowing genetic diseases to be treated. The ultrasound beam is focused onto the tissue to be treated without the need for surgery.

However, the process by which microbubble therapy gets drugs or genes into cells remains controversial. And if the ultrasound parameters are inappropriate, healthy cells can be destroyed. This demands further research to make the technology safe and suitable for human trials.

Sonoporation for targeted drug delivery - experimental

Supervisor: Richard Manasseh
Co-supervisor: Sally McArthur

This project would study the physical processes by which sonoporation works. Advanced laboratory imaging techniques will be used to measure details of the fluid-flow fields around microbubbles driven by ultrasound near cells, extracting data used to quantify sonoporation. Experiments, either by themselves or in combination with numerical or analytic predictions from a sister project, would determine the set of conditions under which sonoporation occurs without damaging the cell.

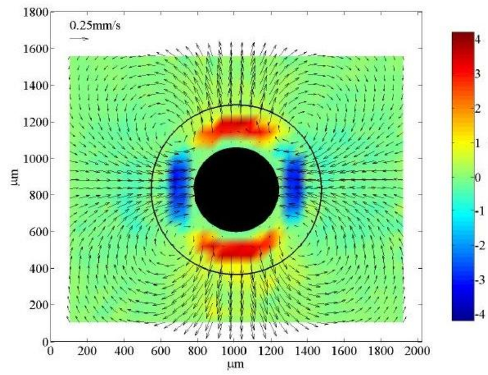


Tho, P., et al. 2007, *J. Fluid Mech.* **576**,191–233.

Sonoporation for targeted drug delivery – numerical / analytic

Supervisor: Richard Manasseh
Co-supervisors: Andrew Ooi (Melbourne University); Petar Liovic (CSIRO)

This project would calculate the physical processes by which sonoporation works. Advanced computer simulation techniques will be used calculate details of the fluid-flow fields around microbubbles driven by ultrasound near cells, predicting sonoporative effects. Calculations, either by themselves or in combination with analytic theory or experimental data from a sister project, would determine the set of conditions under which sonoporation occurs without damaging the cell.



Collis J., et al. 2010, *Ultrasonics* **50**,273–279.

Acoustic measurement of oceanic carbon dioxide absorption

Supervisor: Richard Manasseh
Co-supervisor: Alexander Babanin

The oceans are thought to absorb nearly half of all the carbon dioxide humans put into the atmosphere, but the true amount of greenhouse gas absorbed by the oceans remains unknown. If we could measure this, prediction and control of global warming could be made more accurate. As waves break far out at sea, huge numbers of bubbles are generated and dragged underwater. These bubbles, constantly created across the world's oceans, provide the interfacial area though which greenhouse gases such as CO_2 are absorbed. Can we make measurements allowing the number and sizes of bubbles and hence the interfacial area to be estimated? One possibility is sound. As the waves break, they make a sound with which we are all familiar; these sounds are composed of thousands of pulses from individual bubble-formation events.

http://upload.wikimedia.org/wikipedia/commons/0/0a/Surfers_at_Mavericks.jpg

It is well known that the frequency of sound emitted by a bubble is related to its size, but in a complex bubbly flow such as that under an ocean breaker, lack of knowledge of the amplitude (loudness) of individual bubble emissions makes it difficult to relate measured sounds to the true distribution of bubble sizes. If this problem could be solved, simple, solid-state sensors could be deployed at sea to measure the sounds of breakers. These could be related to satellite images of global wave breaking to calculate CO_2 absorption.

This project will involve two classes of laboratory experiments in which bubbles are formed. Firstly, individual bubble-formation processes will be studied in precision experiments, with emphasis on determining the amplitude as well as frequency of sound created. Secondly, complex groups of bubbles will be formed in a controlled way by a process that simulates an oceanic breaker. Sounds which will be subjected to advanced signal-processing analyses. The aim will be to determine the bubble-size distribution reliably. The study will apply detailed knowledge of the physics of bubble sound emission to inform the signal processing strategies. Finally, data from a real ocean experiment may be obtained and analysed.

As an alternative, students may undertake a mostly theoretical and numerical study on bubble sound emission, using advanced research-only numerical codes. Small-scale laboratory experiments would still be undertaken to validate these computer simulations.