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- Strong commitment to staff development and learning
- Strong commitment to work life and family balance
- Australian bushland setting with free parking
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SCHOOL OF ENGINEERING AND INFORMATION TECHNOLOGY

PhD Scholarship in Quantum Control of Optical Systems

Three years funding at $21,627 (2009 figure), indexed annually, Tax Free; plus a Thesis allowance, Relocation and Travel allowances and 20 days annual recreation leave.

This project will be examining the quantum control of optical systems, and in the first instance we will consider a Cavity Ring-Down (CRD) spectroscopy system. In CRDS light from a laser (either pulsed or CW) is injected into an optical cavity consisting of two or more high-reflectivity mirrors. With the light extinguished, the intensity of the light in the cavity is monitored by detecting the light leaking from the cavity through one of the cavity mirrors. It can be shown that the intensity of the light in the cavity, *I*, decays exponentially following the function $I = I_0 e^{-t/\tau}$, where I_0 is the initial intensity of photons in the cavity, τ is the lifetime or decay constant for photons in the cavity and *t* is time. Absorption of photons by gas-phase molecules within the cavity results in a decrease in the lifetime of photons in the cavity. The absorbance, *A*, can be monitored by measuring τ, if the decay constant of the empty cavity, τ_0, is known, using $A \propto \frac{1}{\tau} - \frac{1}{\tau_0}$.

There are two primary advantages to the CRD spectroscopy that make it an ultra-sensitive absorption technique. First, given modern high-reflectivity mirrors and modest cavity sizes, the path length through a gas-phase sample filling the CRD cavity can exceed a kilometer. Second, the lifetime of photons in the cavity is not dependent on the number of photons injected into the cavity. As a result, the measurement of absorbance is immune to intensity fluctuations of the light source, removing the main source of noise in a typical direct absorption experiment.

A major limitation in state-of-the-art CRD spectrometers is the slow rate at which absorbance information is obtained from the data generated. The traditional method using nonlinear least-squares fitting analysis, obtains τ at maximum rates of only a few hertz while CRD instruments, especially those using CW laser sources, can generate ring-down transients at rates of 10 – 100 kHz. The limitation so far for this technique has been the data analysis methods that "fit" the data to an exponentially decaying waveform. This results in a fall of the rate to determining τ falls well below the signal generation rates.

We have developed a new technique to do this processing that greatly increases the data processing time. The results are very impressive, and the preliminary results show that the new technique can determine τ for the same data at least 1000 times faster. We are now faced with the problem of control and parameter estimation of this system, and pushing the sensitivity to the Quantum Noise Limit.

Our laboratories host a range of state-of-the-art experiments into the generation, manipulation, detection and control of quantum optical systems. The control algorithms developed in this project will be used to improve not only CRDS but also will be implementer on more exotic states such as high frequency squeezed light, single photons and possibly Schroedinger Cat (coherent superposition) states.

The scholarship is located at the UNSW at ADFA campus in Canberra. The Advanced Mid-Infrared Laboratory and the Quantum Control group will jointly supervise this project. For further inquiries regarding the project, please contact: A/Prof. Charles Harb (+61 (02) 6268 8203 or c.harb@adfa.edu.au). Closing Date: 21 October 2009

A written application including a resume and the names and addresses (preferably email) of at least three referees should be submitted to: Charles Harb, School of Engineering and Information Technology UNSW@ADFA, Australian Defence Force Academy, Northcott Drive, Canberra, ACT 2600. You may email your application to: c.harb@adfa.edu.au. For confirmation of receipt of applications please telephone (02) 6268 8203. People from EEO groups are encouraged to apply.