MACQUARIE UNIVERSITY | MQ PHOTONICS RESEARCH CENTRE

NEWSLETTER

Issue 53 – 19 March 2013

MQ Photonics Newsletter is an informal internal publication of the ***MQ Photonics Research Centre*** <http://web.science.mq.edu.au/groups/mqphotonics/>.
We aim to distribute it by e-mail every 3 weeks. Please send copy to <Elizabeth.Bignucolo@mq.edu.au> by 9 a.m. on the due date. **Next due date: to be advised**

Focal Points

This is our first newsletter for the year, its timing somewhat influenced by the usual start of year push to craft and submit ARC grant applications. Best of luck to all Centre members who have grant proposals in the works. One of those applications was by a new Centre member, Dr Thomas Volz. I will take this opportunity to welcome him formally to the Centre.

The Centre has recently turned 5 years old and will be applying for "Mature Centre" status (see http://www.research.mq.edu.au/for/researchers/applying_for_grants/other_external_funding/mqrc) before mid year. A key requirement of this process is that the Centre is reviewed by an independent panel of experts. I am pleased to reveal that Prof John Dudley (Université de Franche-Comté, France), Prof Tanya Monro (Director, Institute for Photonics and Advanced Sensing, University of Adelaide) and Dr Chris Armstrong (Director, Office of the NSW Chief Scientist and Engineer) have kindly agreed to act in this capacity. As part of this review we will hold a mini Research Showcase Day scheduled for the afternoon of the 23rd May. That event will involve a poster presentation session that will give the panel members an opportunity to talk to postgraduate and post-doctoral researchers, and of course, a chance for you to promote your research. I will keep you informed of developments on the review and the Research Showcase as they evolve.

Michael Withford

Congratulations

Congratulations to **Richard Mildren** for having his research mentioned in a recent ARC Annual Report.

Congratulations to **Dayong Jin** for his promotion within the Department of Physics & Astronomy.

Conference

CLEO-PR & OECC/PS 2013

10th Conference on Lasers and Electro-Optics Pacific Rim, and 18th OptoElectronics and Communications Conference / Photonics in Switching 2013

30 June – 4 July 2013, Kyoto International Conference Center, Kyoto, Japan

IMPORTANT DATES

- Early Registration: 1st March to 31st May, 2013
- Post Deadline Paper Submission: 20th May to 20th June, 2013

See website for more details: http://www.cleopr-oecc-ps2013.org/

Conference on Laser Ablation

12th International Conference on Laser Ablation (COLA2013) 6th -11th October 2013, Ischia, Italy

CALL FOR ABSTRACTS

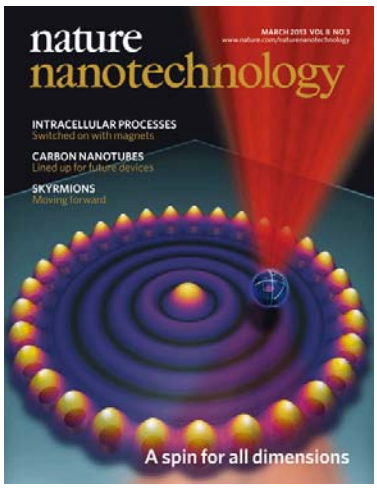
The abstract submission opens on 1st February, 2013
All authors are encouraged to submit their abstract for Oral or Poster Presentation.
More details: www.cola2013.org

IMPORTANT DATES

- Deadline for Abstract submission: 15th March, 2013
- Notification of acceptance of Abstracts: 30th April, 2013
- Early Registration deadline (reduced fee): 1st June, 2013

Publications

Recently published articles

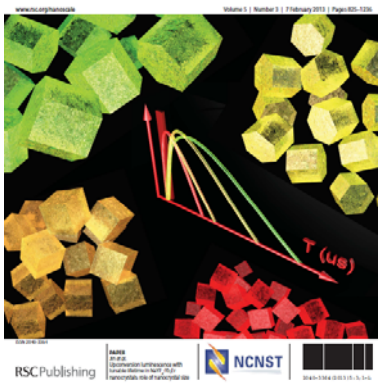


CONGRATULATIONS to Jana for getting onto the cover of **Nature Nanotechnology**.

M Geiselmann, M L Juan, J Renger, **J M Say**, L J Brown, F J Garcı´adeAbajo, F Koppens, R Quidant, "Three-dimensional optical manipulation of a single electron spin", *Nature Nanotechnology*, 8 (3), 175-179 (2013)

Abstract: Nitrogen-vacancy (NV) centres in diamond have the potential to act as qubits for quantum information as well as ultrasensitive probes of both magnetic and electric fields. To fully exploit the capabilities of NV centres, techniques to manipulate them with nanometere accuracy are required. The Letter by Geiselmann *et al.* describes how optical tweezers are used to achieve both translational and angular control of single NV centres in solution. The cover image is an artist's view of one of the experiments that was performed in which a single NV was trapped at the focus of a near-infrared laser beam and was raster scanned to map the distribution of the optical modes around an ensemble of gold nanoislands. Because the technique may be used in a biological environment, it could open new possibilities for the use of colour centres for spin-based cell interrogation.

CONGRATULATIONS to team lead by Ewa and Dayong for getting onto the cover of **Nanoscale**.



J Zhao, Z Lu, Y Yin, C McRae, **J A Piper**, **J M Dawes**, **D Jin**, **E M Goldys**, "Upconversion luminescence with tunable lifetime in NaYF4:Yb,Er nanocrystals: role of nanocrystal size", *Nanoscale*, 5, 944-952 (2013)

Abstract: Despite recent achievements to reduce surface quenching in NaYF4:Yb,Er nanocrystals, a complete understanding of how the nanocrystal size affects the brightness of upconversion luminescence is still incomplete. Here we investigated upconversion luminescence of Yb,Er-doped nanocrystals in a broad range of sizes from 6 nm to 45 nm (cubic or hexagonal phases), displaying an increasing red-to-green luminescence intensity ratio and reduced luminescence lifetimes with decreasing size. By analyzing the upconversion process with a set of rate equations, we found that their asymptotic analytic solutions explain lower decay rates of red compared to green upconversion luminescence. Furthermore, we quantified the effect of the surface on luminescence lifetime in a model where nanocrystal emitters are divided between the near-surface and inside regions of each nanocrystal. We clarify the influence of the four nonradiative recombination mechanisms (intrinsic phonon modes, vibration energy of surface ligands, solvent-mediated quenching, and surface defects) on the decay rates for different-size nanocrystals, and find that the defect density dominates decay rates for small (below 15 nm) nanocrystals. Our results indicate that a defect-reduction strategy is a key step in producing small upconversion nanocrystals with increased brightness for a variety of bioimaging and biosensing applications.

CONGRATULATIONS to Chetan for having a diagram selected for display on **Physical Review E** website as part of their "Kaleidoscope".

C Nichkawde, "Optimal state-space reconstruction using derivatives on projected manifold", *Physical Review E*, 87, 022905 (2013)
DOI: 10.1103/PhysRevE.87.022905

Abstract: A paradigm for optimal state-space reconstruction with nonuniform time delays is proposed. A comparison based on a diffeomorphic measure and a smoothness cost function shows that the proposed methodology achieves a better reconstruction compared to a reconstruction based on time delays that are multiples of the first minimum of mutual information. It is also shown how the proposed methodology is a more reliable approach to determining the embedding dimension.

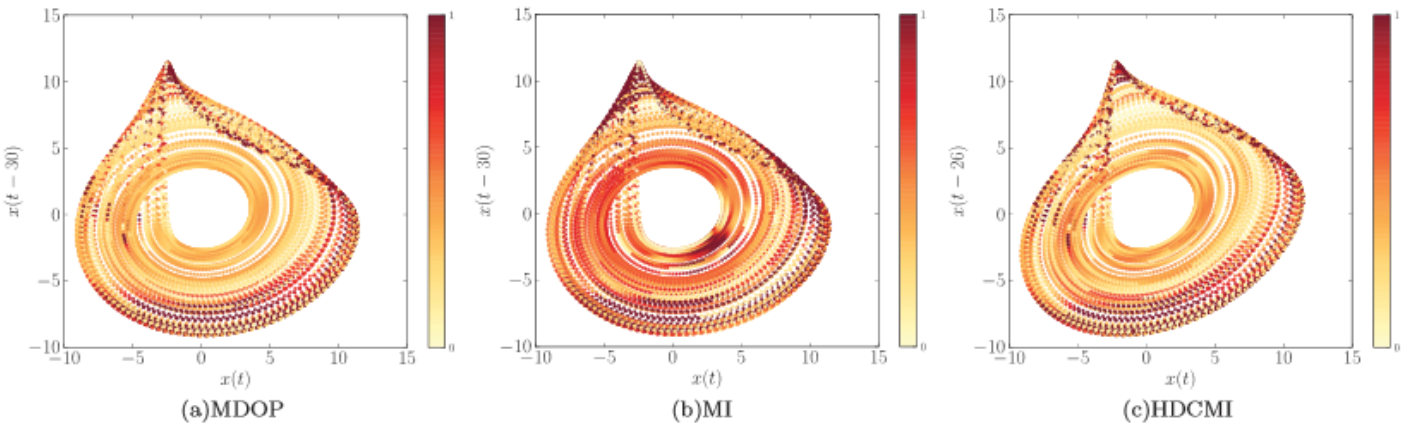


FIG. 8. (Color online) Comparison Lk distribution for Rossler system.

A Arriola, **S Gross**, **N Jovanovic**, N Charles, P G Tuthill, S M Olaizola, **A Fuerbach**, **M J Withford**, "Low bend loss waveguides enable compact, efficient 3D photonic chips", *Optics Express*, 21 (3), 2978-2986 (2013) http://dx.doi.org/10.1364/OE.21.002978

Abstract: We present a novel method to fabricate low bend loss femtosecond-laser written waveguides that exploits the differential thermal stabilities of laser induced refractive index modifications. The technique consists of a two-step process; the first involves fabricating large multimode waveguides, while the second step consists of a thermal post-annealing process, which erases the outer ring of the refractive index profile, enabling single mode operation in the C-band. By using this procedure we report waveguides with sharp bends (down to 16.6 mm radius) and high (80%) normalized throughputs. This procedure was used to fabricate an efficient 3D, photonic device known as a "pupil-remapper" with negligible bend losses for the first time. The process will also allow for complex chips, based on 10's - 100's of waveguides to be realized in a compact foot print with short fabrication times.

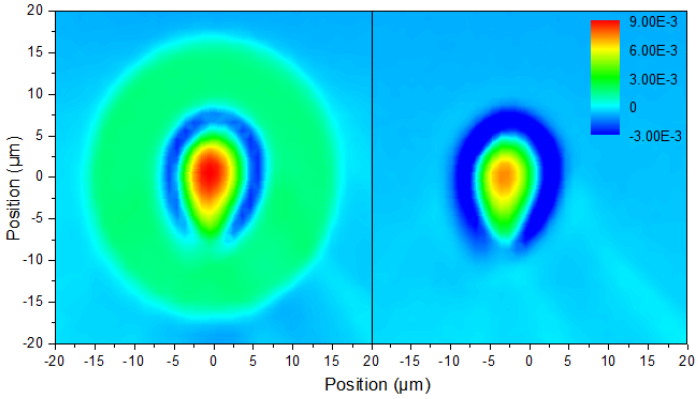


Fig. 4. Refractive index profiles of a 90 nJ waveguide measured before (a) and after annealing (b).

Howell D., Griffin W.L., Piazolo S., **Say J.M.**, Stern R.A., Stachel T., Nasdala L., Rabeau J.R., Person N.J. and O'Reilly S.Y., "A spectroscopic and carbon-isotope study of mixed-habit diamonds: Impurity characteristics and growth environment", *American Minerologist,* (2013). 98(1): **p**. 66-77.

Abstract: Mixed-habit diamonds have experienced periods of growth where they were bounded by two surface forms at the same time. Such diamonds are relatively rare and therefore under-investigated. Under certain physical and chemical conditions, smooth octahedral faces grow concurrently with rough, hummocky cuboid faces. However, the specific conditions that cause this type of growth are unknown. Here we present a large array of spectroscopic data in an attempt to investigate the impurity and carbon-isotope characteristics, as well as growth conditions, of 13 large (>6 mm diameter) plates cut from mixed-habit diamonds. The diamonds all generally have high nitrogen concentrations (>1400 ppm), with the octahedral sectors enriched by 127–143% compared to their contemporary cuboid sectors. Levels of nitrogen aggregation are generally low (2–23% IaB) with no significant difference between sectors. IR-active hydrogen features are predominantly found in the cuboid sectors with only very small bands in the octahedral sectors. Platelet characteristics are variable; only one sample shows a large B′ band intensity in the octahedral sector, with no platelets occurring in the cuboid sector. Other samples either show a small B′ band in both sectors, or just in the cuboid sector, or none at all. These data support a model that shows the concentration-adjusted aggregation rate of nitrogen to be the same in both sectors, whereas the subsequent platelet development is reduced in the cuboid sectors. This is because the interstitial carbon atoms have interacted with *disk-crack-like* defects only found in cuboid sectors, which in turn reduces their chances of aggregating to form platelets. These *disk-crack-like* defects are also thought to be the most likely site for the IR-active hydrogen features and they maybe intrinsic to cuboid growth in mixed-habit

diamonds. When they are graphitized, as they are in all of the diamonds in this study, this may reflect a heating event prior to volcanic exhumation. Spectroscopic analysis of the green cathodoluminescence exhibited by all of the diamonds shows nickel centers to be present in only the cuboid sectors. Carbon isotope data, obtained by secondary ion mass spectrometry, show very little variation in seven of the diamonds. The total range of 217 analyses is –7.94 to –9.61 (±0.15)‰, and the largest variation in a single stone is 0.98‰. No fractionation in carbon isotopes is seen between octahedral and cuboid sectors at the same growth horizon. These data suggest that the source fluid chemistry, as well as pressure, temperature, and oxygen fugacity were very stable over time, allowing such large volumes of mixed-habit growth to occur. The high concentration of impurities, namely nitrogen and hydrogen, is probably the critical factor required to cause mixed-habit growth. The impurity and isotopic data fall in line with previous modeling based on diamond growth from reduced carbonates with the loss of a 13C-enriched CO2 component.

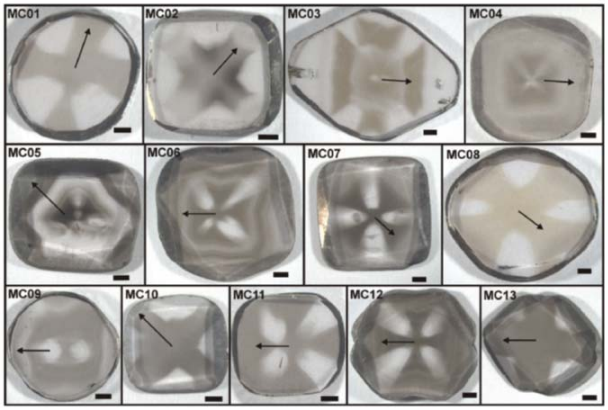


Figure 2. Images of the 13 mixed-habit diamonds analysed in this study. All are doubly polished plates. All but two are cut within 10º of a {100} face, MC03 and MC05 are cut parallel to a {110} face. The black arrows point in a <100> direction. The black bars represent 1mm scales. (Color online).

Blaber S.B., Hill C.J., Webster R.A., **Say J.M.**, Brown L.J., Wang S.-C. (M.), Vesey G. and Herbert B.R, "Effect of labeling with iron oxide particles or nanodiamonds on the functionality of adipose-derived mesenchymal stem cells", *PLOS ONE*, (2013). 8(1): **p**. e52997.

Abstract: Stem cells are increasingly the focus of translational research as well as having emerging roles in human cellular therapy. To support these uses there is a need for improved methods for in vivo cell localization and tracking. In this study, we examined the effects of cell labeling on the in vitro functionality of human adipose-derived mesenchymal stem cells. Our results provide a basis for future in vivo studies investigating implanted cell fate and longevity. In particular, we investigated the effects of two different particles: micron-sized (0.9 mm) fluorescently labeled (Dragon Green) superparamagnetic iron oxide particles (M-SPIO particles); and, carboxylated nanodiamonds of ,0.25 mm in size. The effects of labeling on the functionality of adipose-derived MSCs were assessed by in vitro morphology, osteogenic and adipogenic differentiation potential, CD marker expression, cytokine secretion profiling and quantitative proteomics of the intra-cellular proteome. The differentiation and CD marker assays for stem-like functionality were not altered upon label incorporation and no secreted or intra-cellular protein changes indicative of stress or toxicity were detected. These in vitro results indicate that the M-SPIO particles and nanodiamonds investigated in this study are biocompatible with MSCs and therefore would be suitable labels for cell localization and tracking in vivo.

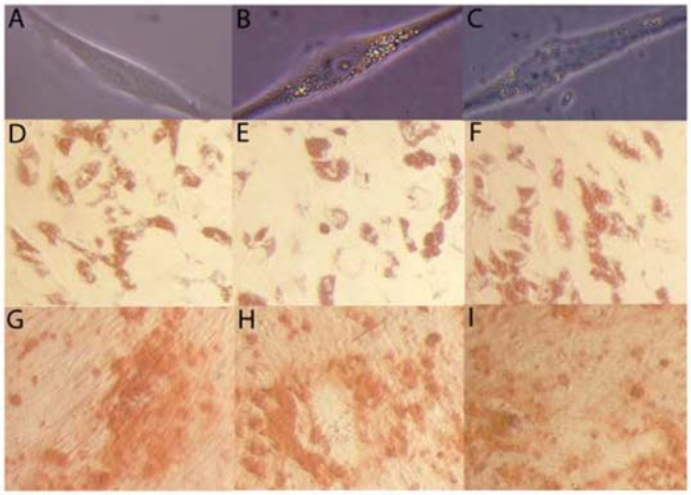


Figure 1: Morphology and differentiation potential of control and labeled adipose-derived mesenchymal stem cells.

Mitsuhiko Kono, **Yabai He**, Kenneth G H Baldwin, **Brian J Orr**, "Sub-Doppler two-photon spectroscopy of 33 Rydberg levels in atomic xenon excited at 205–213 nm: diverse isotopic and hyperfine structure", Journal of Physics B: Atomic, Molecular & Optical Physics 46 (3), 035401 (2013); 16 pp.; published online 22 January 2013; http://iopscience.iop.org/0953-4075/46/3/035401/; doi:10.1088/0953-4075/46/3/035401

Abstract: Isotope energy shifts and hyperfine structure have been measured for 33 high-energy Rydberg levels of atomic xenon by sub-Doppler two-photon excitation spectroscopy, using narrowband pulses of coherent ultraviolet light at 205–213 nm generated by nonlinear-optical conversion processes. Rydberg levels are accessed at two-photon excitation energies in the 97 300–94 100 cm−1 range where isotope energy shifts and hyperfine structure have rarely been resolved; these Rydberg levels are 5p5 np [1/2]0 (n = 9–13), 5p5 np [3/2]2 (n = 9–13), 5p5 np [5/2]2 (n = 9–17), 5p5 nf [3/2]2 (n = 6–14) and 5p5 nf [5/2]2 (n = 6–10). The sub-Doppler spectra display diverse hyperfine-coupling effects, for which least-squares-fit spectroscopic parameters reflect the influence of angular momentum.

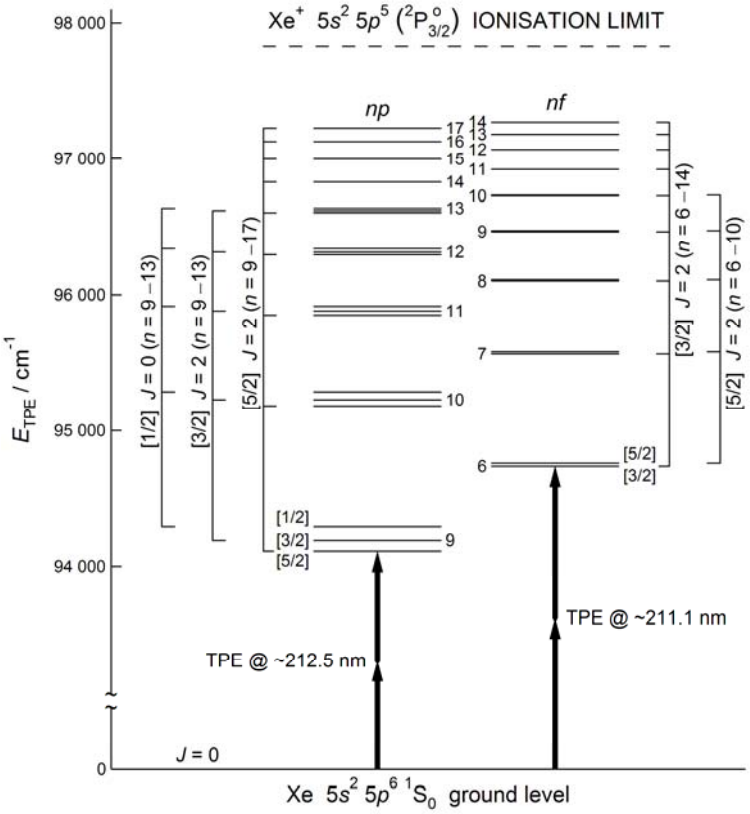


Figure 1. Schemes for sub-Doppler two-photon excitation (TPE) of a Xe atom from its $5s^2\,5p^6\ ^1S_0$ ground level to high-energy Rydberg levels, either $5s^2\,5p^5(^2P^o_{3/2})\,np$ (on the left) or $5s^2\,5p^5(^2P^o_{3/2})\,nf$ (on the right), as reported in this paper. Vector coupling between the angular momentum $\boldsymbol{j}$ of the $Xe^+\ ^2P^o_{3/2}$ core and the orbital angular momentum $\boldsymbol{l}$ of the Rydberg electron (with principal quantum number n) generates the square-bracketed quantum numbers, which then couple to the Rydberg-electron spin $\boldsymbol{s}$ to yield the quantum number J for each level; figure 1 shows only levels with even-numbered values of J, which are accessible by TPE from the $J = 0\ ^1S_0$ ground level. $J = 2$ levels for the magnetic isotopes ^{129}Xe and ^{131}Xe are further split by hyperfine coupling into F-levels (not shown in figure 1). All levels shown here converge to the $5s^2\,5p^5(^2P^o_{3/2})$ ionisation limit at 97 833.8 cm^{-1} [5,6] for the Xe^+ ionic core.

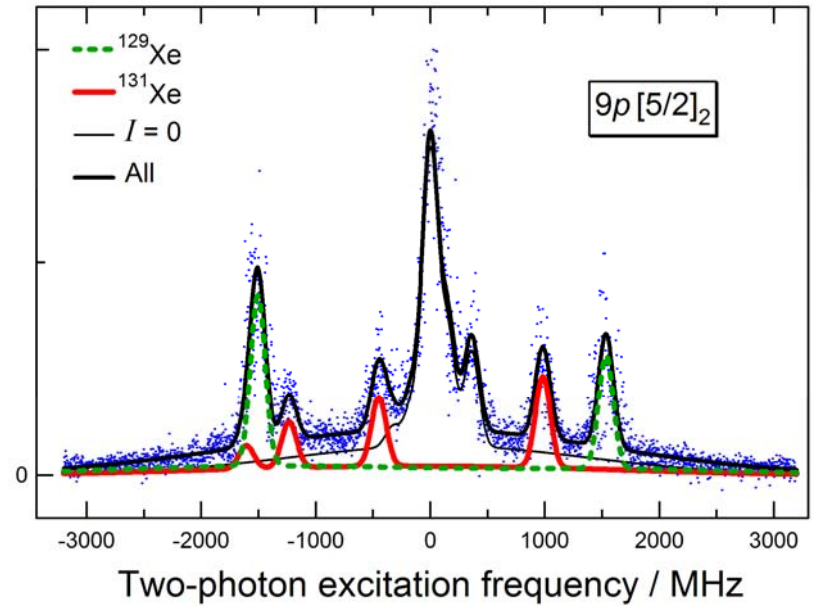


Figure 4. Sub-Doppler TPE spectrum (with Doppler-limited pedestal) for Xe $5p^6 \rightarrow 5p^5\ 9p\ [5/2]_2$ recorded at $\lambda_{UV} \approx 212.5$ nm, with the combined profile of the five $I = 0$ isotopic peaks shown in light black, the hyperfine structure for the ^{129}Xe ($I = 1/2$) and ^{131}Xe ($I = 3/2$) isotopes shown as a dashed green line and as a solid red line, respectively, and the net profile shown in bold black.

Note: This is just one of many diverse forms of sub-Doppler TPE spectrum of Xe with hyperfine structure that posed a challenge to our understanding!

Seminars

MQ Photonics Seminars:

Time: 11am, Fri 15th March TOPIC: CW Tunable Raman laser pumped by VECSEL	Place: E7B 264	Presented by: Jipeng Lin
Time: 11am, Fri 5th April TOPIC: TBA	Place: TBA	Presented by: Ondrej Kitzler
Time: 11am, Fri 19th April TOPIC: Journal papers- Responding to reviewers and an editors perspective	Place: TBA	Presented by: Brian Orr and Mike Steel
Time: 11am, Fri 26th April TOPIC: TBA	Place: TBA	Presented by: Sebastian Stark

People and Progress

MQ Photonics Student Researcher Award 2012

Research report by **Reece Roberts**, "Mode Structure in CW Single Longitudinal Mode Pumped Diamond Raman Lasers".

Abstract: Linewidth broadening in Raman lasers has been investigated comprehensively in gases but not in crystals. We would like to find whether the Raman laser linewidth in crystals is comparable to the input linewidth or if it will be broadened as is shown in Figure 1. The pump source is a CW fibre based system with a single longitudonal mode (SLM) structure. The Raman laser is a double pass cavity wth diamond acting as the Raman crystal medium.

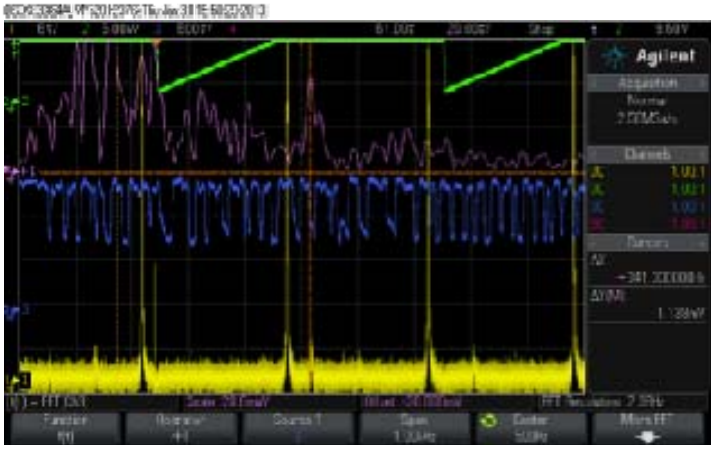


Figure 5: Fabry-Perot results showing the single mode in yellow for each green input voltage ramp.

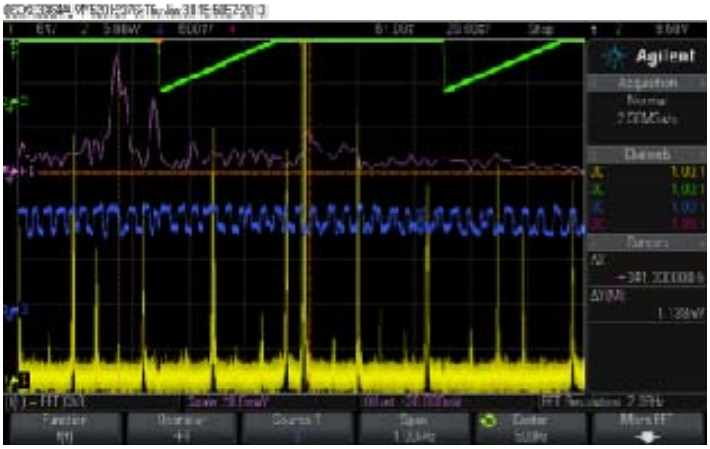
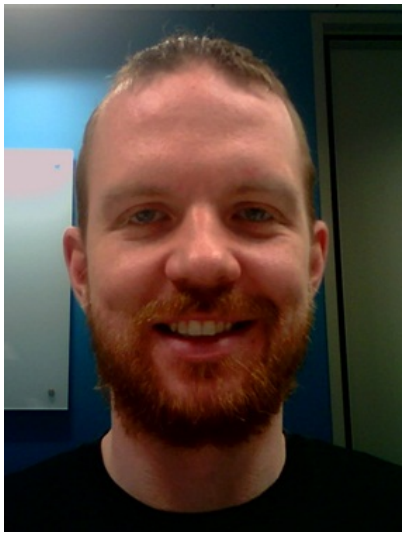


Figure 6: Fabry-Perot results showing the unstable mode structure in yellow for each green input voltage ramp.



Welcome to Luke Helt

Dr Luke Helt has joined the CUDOS group to work on theoretical problems in integrated quantum photonics and balance out our growing experimental team in this area. Luke has just completed his PhD at the University of Toronto studying theoretical treatments of spontaneous processes in quantum nonlinear optics. Such processes are a key source of photon pairs for quantum information experiments and are a major focus of the CUDOS program in quantum processing.

Many of you may have met Luke during his previous research visit about a year ago. His stays seem to be highly correlated with extended miserable weather along the eastern seaboard; whether this is correlation or causation will be an ongoing subsidiary research topic.

You'll find Luke in the quantum open plan space. Please say hi.

Michael Steel

Welcome to Thomas Volz

Dr Thomas Volz is a senior lecturer at Macquarie University specializing in solid-state quantum optics and quantum photonics. During his PhD, Dr Volz carried out experiments on ultracold atomic and molecular quantum gases in optical lattices in the group of Prof Gerhard Rempe at the Max-Planck Institute of Quantum Optics in Garching (Germany). He was awarded his PhD in 2007 through the Technical University of Munich (Germany). Right after, Dr Volz changed fields and joined Prof Atac Imamoglu's Quantum Photonics Group at ETH Zurich (Switzerland) where he carried out experiments on semiconductor cavity QED. At Macquarie University, Dr Volz will continue his research in semiconductor quantum optics, but in addition, will lead the nano-diamond lab at Macquarie University which specializes in quantum sensing and metrology using nano-diamond. With the start of his contract at Macquarie University on 1 February 2013, Dr Volz was appointed a CI within EQuS.

Welcome to Sandya Clement

Sandya joined us as a PhD. Her project will be about X-ray excited nanoparticles. Sandya will be working with me and Wei Deng, our alumnus and a DECRA fellow commencing in Feb 2013.

Ewa Goldys

Congratulations to Josh Toomey and his wife Alyssa on the arrival of their baby son, Harrison. Josh reports that both mother and baby are doing well.

Deb Kane

OSA Student Chapter update

CUDOS workshop 2013

This year's CUDOS workshop saw a host of highly competitive student outreach competitions. MQ was represented strongly by Nick Cvetojevic and Alex Arriola. Nick gave an outstanding presentation on a new outreach idea called "Pinterest", which was well received by all. Nick also presented Macquarie's entry to the annual student competition; an exciting video about interweaving CUDOS with mobile applications, which was both informative and hilarious.

Nick Cvetojevic giving a presentation on outreach (left), and Judith Dawes Presenting Nick with a student outreach prize (right).

Upcoming events

- OSA student chapter elections 21st March 4pm
- Astronomy open night 7th May (helpers needed!!)

Thomas Meany

Job Opportunities

Helen Pask has Job Opportunities on 2 projects (could be combined into a single position for 1 year). Please contact her if you are interested in finding out more.

1) Research Assistant or Associate required: part-time for approx. 6 months at 0.5 fraction , available from February

Project Description: "Optical sensing of tissue temperature for applications in ophthalmology"

This feasibility study will investigate whether Raman spectroscopy is useful for determining the temperature of vessels in the eye undergoing photocoagulation. Such a capability would be of considerable value because it would enable the surgeon to know when the correct temperature has been reached to achieve the desired clinical effect, and could be combined with retinal imaging for computer-controlled surgery. We will also investigate whether Raman spectroscopy could be used for other diagnostic purposes.

2) Research Assistant or Associate required: full time for approx. 12 months, available from February

Project Description: "Optical remote sensing of water temperature and salinity"

This study, funded by the NSW Environmental Trust aims to apply Raman spectroscopy to the determination of sub-surface water profiles. It will combine some laboratory work with the design and evaluation of a field-deployable prototype for insitu measurements, at Chowder Bay (SIMS facility) and Sydney Harbour.