Focal Points

We are all awaiting the outcome of our bid to become a Mature Macquarie University Research Centre. In the meantime, the Vice Chancellor has released his green paper “Our University: A Framing of Futures” (available at http://vc.mq.edu.au/our-university-a-framing-of-futures/) which sets out a framework within which all new Macquarie University strategies will be developed, including revised research strategies. Accordingly, our new Deputy Vice Chancellor Research (Prof. Sakkie Pretorius) has put on hold applications for new MQ Research Centres and Mature Research Centre status will only be approved for an interim one year period while he reviews the whole MQ Research Centres scheme. From my perspective we gain much from our collegial membership of a vibrant and productive research centre, which is also a showcase of research excellence for the University. Future research centre policy will be driven by new Macquarie University strategic goals which may well align with recently articulated national priorities for STEM (Science, Technology, Engineering and Mathematics) as articulated in the recent position paper on STEM released from the Office of the Chief Scientist (http://www.chiefscientist.gov.au/). This document proposes that Australia’s STEM strategy should: focus on priority areas where we have competitive advantage or critical needs, and build scale so that we have the capacity to make real and enduring differences. Nationally this may lead to a greater emphasis on ‘mission-directed’ STEM R&D, and within Macquarie University these themes are also likely to shape future strategies. The VC has expressed a desire for greater differentiation from other Australian universities (e.g. the Group of Eight). What does this mean for MQ Photonics? Well, encouraged by our recent very positive external review, we will lobby for a strengthened Centres scheme to build further on our many years of success.

David Coutts – guest editor

MQ Photonics - Image of the month – by Prof Ewa Goldys

Congratulations

Congratulations to the following people on their success in the latest ARC Linkage announcement:

- **Mick Withford** (with Tanya Monro and Peter Johnson), “Compact and versatile chip lasers for three-dimensional mine surveying” with Maptek Pty Ltd;

David Coutts

**Jim Piper’s Festschrift**

To mark Jim Piper’s retirement, a series of events was held across campus, including a most enjoyable Festschrift in his honour on 20 June. It was a great pleasure to see so many of Jim’s colleagues and former students gather for to celebrate his career through an excellent program of invited talks followed by a celebration dinner.

![Danny Brown, Jim Piper, Cathy Foley and Larry Marshall, Pu Wang, Jim Piper and Denis Hall.](image1)

![Just some of Jim Piper’s past and present graduate students (with a couple extras). Photos by: Effy Alexakis](image2)

**Jim Piper’s afternoon tea**

On the 27th June, the Department of Physics and Astronomy organised a surprise afternoon tea for Jim Piper, marking his retirement as DVC(Research) and welcoming him back to the Department as Emeritus Professor of Physics. Jim had no idea he was coming to physics and enjoyed viewing our hologram “To Absent Friends” while catching up with guests that included former students John Nestel, Joe Narai, Andy Scott, Emma Mitchell, Antonio, and retired colleagues Ron Brown, the Vaughans, the Johnsons, Gunther...
Rossmanith, and the wonderful creator of our hologram – Paula Dawson. Judith read a moving message from Jim’s former boss at Oxford, Colin Webb, and presented him with gifts that included a laser chess set, an artistic canvas of word art comprising the names of around 50 completed MSc and PhD students, a scroll of PhD and MSc thesis titles and a unique thyratron-inspired sculpture. The highlight was a totally awesome, edible, metal vapour laser (cake) complete with Brewster windows, mirrors and oven, as well as goggles and manual all on an optical bench. Special thanks to Barbara Zitterman Iza Spaleniak and Tristan Temple.

Helen Pask

The largest holographic artwork in the world, To Absent Friends, by artist Paula Dawson. Originally commissioned by Janet and Robert Holmes a Court in 1987, the artwork was lost and the three plates, shown together for the first time in Australia, are all that survive. To Absent Friends recreates a real bar over the course of New Year’s Eve, with images captured at 5pm, midnight, and 3:30am. Read more: http://www.mq.edu.au/newsroom/2010/07/20/hologram-exhibition-celebrates-50-years-of-the-laser/ixzz2YbthXZQQ
Key Dates
Submission deadline: Thursday 12\textsuperscript{th} September
Notification of Authors: Friday 5\textsuperscript{th} October
Early registration deadline: Friday 1\textsuperscript{st} November
For more details, see: \url{http://2013anzcop.com/}

Conference and workshop reports

\textbf{COE hosts Sino-Australia Workshop on Nanophotonics}
College of engineering (COE) at Peking University, 27\textsuperscript{th} to 28\textsuperscript{th} June 2013

Scholars from the University of Adelaide and Macquarie University in Australia attended the workshop along with Peking University researchers. The local committee chair of the workshop is Dr. Xi Peng, Associate Professor of the Department of Biomedical Engineering, COE.
Professor Ren Qiushi, departmental chair of Biomedical Engineering, firstly welcomed all international attendees from the University of Adelaide and Macquarie University, before introducing the research highlights of the Dept. of Biomedical Engineering as well as other institutions at Peking University. “There are many potential opportunities of collaboration between the three universities, especially in nanophotonics
and biophotonics. I hope that three universities can utilize this workshop as a friendly communication platform, to promote research cooperation and exchanges in the related fields,” he emphasized. Representatives from the University of Adelaide and Macquarie University also introduced their own universities and their researches on nanophotonics and bio-application. They expressed willingness to have a long-term cooperation with Peking University.

During the two days’ workshop, the attendees exchanged their research highlights on single molecule, nanophotonics, bio-imaging, and laser techniques. As there were many similarities between these researches, they achieved initial intent of cooperation on many fields.

Besides the workshop, scholars from the University of Adelaide and Macquarie University had a visit to Biodynamic Optical Imaging Center (BIOPIC) and other labs. 

http://english.pku.edu.cn/News_Events/News/Focus/10404.htm

Publications

Recently published book chapter


Abstract: Traditional Australian Aboriginal bark paintings are painted on stringybark tree bark prepared by firing and flattening. The pigments used are natural ochres, white clays, and black powders from charcoal or manganese nodules. Plant and animal based binders are used to bind the pigment. Past treatments have used varnishes and various consolidants to protect and hold the fragile pigments to the bark. The coatings and consolidants cause alteration of the appearance of the painting. Removal and modification of these coatings (polyurethane) and consolidants (paraloid B72, polyvinyl butyral, gelatin) by laser processing is investigated with a view to returning the painting to something closer to its as-painted appearance. Ultra-violet and green nanosecond pulsed laser systems, and a sub-picosecond pulsed laser at 800nm have been used. Removal of polyurethane has been demonstrated with a 266 nm Nd:YAG laser-based output. A 800 nm, sub-picosecond Ti:sapphire laser caused bubbling of polyurethane with a positive effect on the appearance of the white pigment. Partial laser removal of “consolidants” has been possible in circumstances where it is found, that for reasons of the state of the painting when consolidated, the “consolidant” is in a form of a coating rather than being fully incorporated into the pigment and bark as normally expected. Laser processing has also been shown to have great promise for learning about the state of pigment binding in these paintings by essentially non-destructive spot testing.
Recently published articles

M A Startsev, D W Inglis, M S Baker, E M Goldys, “Nanochannel pH Gradient Electrofocusing of Proteins”, Analytical Chemistry, published online 2nd July 2013. PMID: 23819922

Abstract: We demonstrate matrix-free pH gradient electrofocusing of proteins within an 85-nm deep nanochannel. In contrast to conventional isoelectric focusing where the fluid does not move, this pH gradient method traps protein molecules flowing through a channel by balancing electric forces due to pH-dependent protein charge and viscous drag forces caused by electro-osmosis. The nanoscale depth of the device and the low voltage used limit convection relative to diffusion, thus producing a stable focused band of protein. R-phycoerythrin (RPE) and Dylight labeled streptavidin (Dyl-Strep) were focused within a nanochannel using applied voltages between 0.4 and 1.6 V. Concentration enhancement factors of over 380 have been achieved within 5 minutes. Varying the buffer pH (between 2.7 and 7.2) at the boundaries of the nanochannel affected the shape of the focused bands. For RPE, a pH span of 4.5 (pH 2.7 to 7.2) yielded the narrowest peak while a span of 2.4 (pH 2.7 to 5.1) produced a significantly wider peak. Such matrix-free nanofluidic devices with pH gradient electrofocusing may enable on-chip integration of electro-spray mass spectrometry offering labor savings and enhanced performance.

Figure 2: Schematic of the nanochannel device indicating the fluid flow direction (red dotted line) within each microchannel. The Inset shows the nanochannels with the top silica layer removed and a vertical slice taken to more clearly illustrate the geometry of the channels. Depth of microchannels is 12.5 ± 0.5 μm. Nanochannels are W = 20 μm wide, L = 100 μm long and D = 85 ± 5 nm deep.


http://dx.doi.org/10.1364/OL.38.002588

Abstract: We report a large mode-area holmium-doped ZBLAN waveguide laser operating at 2.9 μm, which was pumped by a 1150 nm diode laser. The laser is based on ultrafast laser inscribed depressed cladding waveguides fabricated in uniformly rare-earth-doped bulk glass. It has a threshold of 28 mW and produced up to 27 mW of output power at an internal slope efficiency of approximately 20%.

Fig. 1. (a) Energy level diagram of Ho3+ in ZBLAN glass. (b) End-on microscope image of the waveguide.

Abstract: We report the first Yb:ZBLAN and Yb:IOG10 waveguide lasers fabricated by the fs-laser direct-writing technique. Pulses from a Titanium-Sapphire laser oscillator with 5.1 MHz repetition rate were utilized to generate negative refractive index modifications in both glasses. Multiple modifications were aligned in a depressed cladding geometry to create a waveguide. For Yb:ZBLAN we demonstrate high laser slope efficiency of 84% with a maximum output power of 170 mW. By using Yb:IOG10 a laser performance of 25% slope efficiency and 72 mW output power was achieved and we measured a remarkably high refractive index change exceeding $\Delta n = 2.3 \times 10^{-2}$.

Fig. 6 Output power curves for Yb:IOG10 (left) and Yb:ZBLAN (right) with different OC-mirrors, inset showing far field mode of each guide at maximum output power.


Abstract: We present a model for a Yb-doped distributed Bragg reflector (DBR) waveguide laser fabricated in phosphate glass using the femtosecond laser direct-write technique. The model gives emphasis to transverse integrals to investigate the energy distribution in a homogenously doped glass, which is an important feature of femtosecond laser inscribed waveguide lasers (WGLs). The model was validated with experiments comparing a DBR WGL and a fiber laser, and then used to study the influence of distributed rare earth dopants on the performance of such lasers. Approximately 15% of the pump power was absorbed by the doped “cladding” in the femtosecond laser inscribed Yb doped WGL case with the length of 9.8 mm. Finally, we used the model to determine the parameters that optimize the laser output such as the waveguide length, output coupler reflectivity and refractive index contrast.

Fig. 1 (a) DIC top-view image of a waveguide (b) respective end-on cross section image.


Abstract: We report the demonstration of a single-longitudinal-mode fiber laser operating at 2914 nm, which exhibits a spectrometer-limited linewidth of <0.4 nm, in a 49 mm long holmium/praseodymium co-doped ZBLAN fiber. Narrow-linewidth feedback is provided by a fiber Bragg grating inscribed directly in the ZBLAN fiber using the femtosecond laser point-by-point technique. Measurements of the temporal stability and coherence confirm that the laser is operating on a single longitudinal mode.

Fig. 2. DIC micrographs of (a) PbP FBG in ZBLAN fiber inscribed with 190 nJ pulses and (b) PbP FBG inscribed in silica fiber (SMF-28e) using similar pulse energy (200 nJ). Microvoids are observable in the silica FBG but not in the ZBLAN PbP FBG.

Abstract: We demonstrate long-distance (≥100-km) synchronization of the phase of a radio-frequency reference over an optical-fiber network without needing to actively stabilize the optical path length. Frequency mixing is used to achieve passive phase-conjugate cancellation of fiber-length fluctuations, ensuring that the phase difference between the reference and synchronized oscillators is independent of the link length. The fractional radio-frequency-transfer stability through a 100-km “real-world” urban optical-fiber network is $6 \times 10^{-17}$ with an averaging time of $10^3$ s. Our compensation technique is robust, providing long-term stability superior to that of a hydrogen maser. By combining our technique with the short-term stability provided by a remote, high-quality quartz oscillator, this system is potentially applicable to transcontinental optical-fiber time and frequency dissemination where the optical round-trip propagation time is significant.


Abstract: We present a technique for the simultaneous dissemination of high-precision optical-frequency signals to multiple independent remote sites on a branching optical-fiber network. The technique corrects optical-fiber length fluctuations at the output of the link, rather than at the input as is conventional. As the transmitted optical signal remains unaltered until it reaches the remote site, it can be transmitted simultaneously to multiple remote sites on an arbitrarily complex branching network. This technique maintains the same servo-loop bandwidth limit as in conventional techniques and is compatible with active telecommunication links.
### Seminars

#### MQ Photonics Seminars:

<table>
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<tr>
<th>Time: 11am, Fri 19th July</th>
<th>Place: E6B 136</th>
<th>Presented by: Dr Jia Du (CSIRO)</th>
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| **TOPIC:** High-Tc superconducting devices for microwave and terahertz applications  
**Abstract:** CSIRO Applied Superconductivity Group has a long-term effort in research and development of superconducting electronic devices and systems for various practical applications. In this talk, a brief overview of CSIRO research activities on developing high-Tc superconducting (HTS) Josephson junction-based devices and their applications such as SQUIDs for mineral and exploration as well as some other applications will be presented. The focus of the talk will then be directed to follow two areas: Novel uW wireless devices for communication; and terahertz (THz) as an emerging field. |

Dr Du joined CSIRO in 1995 and initially worked on surface acoustic biosensors. Since 1998, she has been working with the Applied Superconductivity Research Group in developing superconducting electronic devices for various applications, and she now leads the development of high-temperature superconducting Josephson junction devices for microwave and terahertz applications. She has co-authored over 140 journal and conference papers. |

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<tr>
<th>Time: 11am, Fri 26th July</th>
<th>Place: E6B 136</th>
<th>Presented by: Dr Olivier Alibart (University Sophia-Antipolis)</th>
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| **TOPIC:** A versatile source of polarisation entangled photons for quantum network applications  
**Abstract:** Periodically poled lithium niobate waveguides (PPLN/W) are nowadays considered one of the most useful toolboxes for quantum communication experiments. Thanks to high optical confinement over longer lengths than bulk configurations (a few cm), such structures provide very efficient nonlinear interactions, both in down- and up-conversion regimes. Within the framework of enabling quantum communication over long distances, PPLN/Ws are key ingredients for building ultra-bright sources of energy-time, time-bin, as well as polarisation entangled pairs of photons, up-conversion based detectors and photonic quantum interfaces, as well as quantum relays in the entanglement swapping configuration. I'll introduce the in and out of experimental quantum information and I'll build on describing the realisation of a versatile and practical approach for generating high-quality polarisation entanglement in a fully guided-wave fashion. Our setup relies on a high-brilliance type-0 waveguide generator producing paired photons at a telecoms wavelength associated with an advanced energy-time to polarisation transcriber. The latter is capable of creating any pure polarisation entangled state, and allows manipulating single photon bandwidths that can be chosen at will over five orders of magnitude, ranging from 25 MHz to 100 GHz. Such a source candidate for a wide range of network applications, ranging from dense division multiplexing quantum key distribution to heralded quantum memories and repeaters. |

Dr Alibart completed his PhD in Nice in 2004 and undertook a 2 year post-doc position in John Rarity's group at Bristol. He is now a lecturer at the University of Nice and a member of the Quantum and Information with Light and Matter group. |

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<tr>
<th>Time: 11am, Mon 29th July</th>
<th>Place: E6B 136</th>
<th>Presented by: A/Prof Fedor Gubarev (Tomsk Polytechnic University, Russia)</th>
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| **TOPIC:** Metal vapor lasers and their applications for diagnostics  
**Abstract:** CuBr vapor lasers and brightness amplifiers on their basis operate in a visible spectral range at wavelengths of 510.6 and 578.2 nm. CuBr lasers and their analogs (conventional copper vapor lasers (CVL), kinetically-enhanced CVLs and H-Br lasers) can be successfully used in a number of areas including micromachining systems and active optical systems with brightness amplification. The topic is devoted to recent results in metal vapor lasers achieved in Tomsk and applications of these lasers for diagnostics. Three main directions of study are discussed: high frequency operation, using capacitive discharge for excitation of CuBr lasers and application of CuBr lasers in laser projection systems for visualization of objects through intensive stray lighting. Examples include using laser monitor (laser projection microscope) for observation of processes through shielding background lighting: interaction of powerful energy with matter, combustion processes (eg. self-propagating high-temperature synthesis), and plasma-induced processes. To increase the time resolution of the system and image quality we suggest the scheme in which the image amplifier and high-speed camera operate synchronously. The future development of laser monitors is also discussed. |

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<th>Time: 12Noon, Fri 2nd August</th>
<th>Place: C8A 310 (Senate)</th>
<th>Presented by: Prof. Thorsten Ackermann (Strathclyde University)</th>
</tr>
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| **TOPIC:** Nonlinear photonics in VCSELs-solitons and spin oscillations  
**Abstract:** Vertical-cavity surface-emitting lasers (VCSELs) show a very complex phenomenology of instabilities due to the presence of a large number of spatial, spectral and polarization degrees of freedom interacting with |

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nonlinearities and disorder. Though the resulting limitations of their spatial and temporal coherence are usually considered to be a nuisance in applications, a proper understanding and design of the underlying self-organization processes can lead to new functionalities and devices. By frequency-selective feedback, emission can be funnelled into coherent microlasers which can be optically controlled, i.e. switched-on and off by external optical beams. These microlasers are a special form of a spatial soliton. We demonstrate frequency- and phase-locking of these laser solitons defying cavity disorder. Vortex solitons are observed representing high-order solitons. Spin dynamics can lead to ultra-fast self-oscillations based on polarization oscillations induced by birefringence, which are not subject to the usual limits for laser modulation given by the damping intensity of relaxation oscillations.

### People and Progress

In August we said farewell to A/Prof Fedor Gubarev from who was a Visiting Fellow in MQ Photonics for three months. During his visit we explored energy scaling and tenability of cerium lasers pumped by nanosecond microchip lasers. Fedor also gave an interesting seminar where he showed how copper bromide laser brightness amplifiers can be used to image in hostile environments such as studying the combustion of solids. This prompted us to revisit an old idea, where a copper vapour laser brightness amplifier is used to project 3-d images. We used the filters from 3-d movie glasses to produce a 3-d image that could be observed when wearing matching glasses. Fedor has returned home with many new skills, ideas for further research and very fond memories of all in MQ Photonics.

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<tr>
<th>Time: 11am, Fri 16th August</th>
<th>Place: E6B 2.300</th>
<th>Presented by: Prof. Takashige Omatsu (Chiba University, Japan)</th>
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<td><strong>TOPIC:</strong> Nonlinear optics by vortex lasers</td>
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<td><strong>TOPIC:</strong> Towards a polymorphic phase change device</td>
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A/Prof Fedor Gubarev and David Coutts in front of an image of a microchip displayed using a laser projection microscope with a magnification of about 1000x.

David Coutts
We would like to extend a warm welcome to the group to new OptoFab (ANFF) member **Alex Stokes**. Alex will be working in laser machining and direct write processing in the coming year joining us from the undergraduate program here at MQ.

Graham Smith

Visiting researchers **Dr Olivier Alibart** and **Mr Lufti Arif Bin Ngahwho**, from the University of Nice in France, joined the CUDOS group for an extended visit in July. Their visit is associated with an ongoing collaborative research program developing an integrated, multiplexed single photon source for quantum optics as part of the joint FP7 – Information and Communication Technologies 2009 call – Quantum Integrated Photonics (QUANTIP). Following a successful research visit by Thomas Meany to Nice earlier this year, we have continued this initiative at the Macquarie labs and successfully produced on-chip, 4 heralded photons. The photo shows Thomas and Lufti celebrating that success.

Mick Withford
OSA Student Chapter updates

On Monday 22nd July, students from Chifley College came to Macquarie University to get familiar with various disciplines of science.

The MQ OSA Student Chapter members prepared the famous Laser Graffiti and helped with other physics experiments including music on the light beam, how to guide light, and light spectrum measurements. We've also had fun to explain the Photonics Simulator (http://web.science.mq.edu.au/groups/cudos/education/Simulator.swf) which graphically demonstrates how photonic circuits work. Let me know if someone can complete all 15 challenges! Big thanks to Judith for organizing the visit and Adam, Helen, Ali, Felix, Luke, Vincent, Jipeng and Warrier for their help.

Ondraj Kitzler