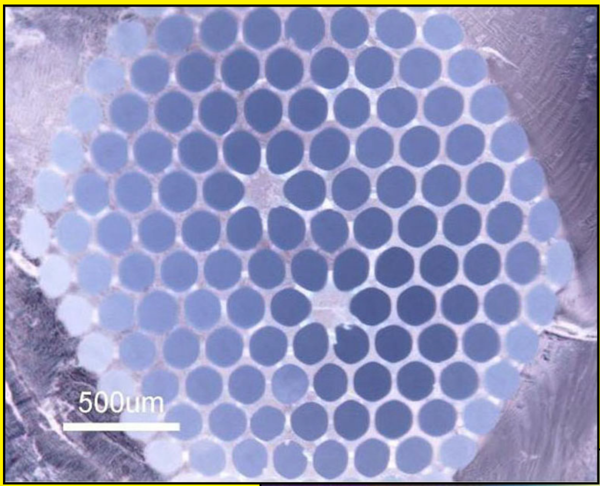
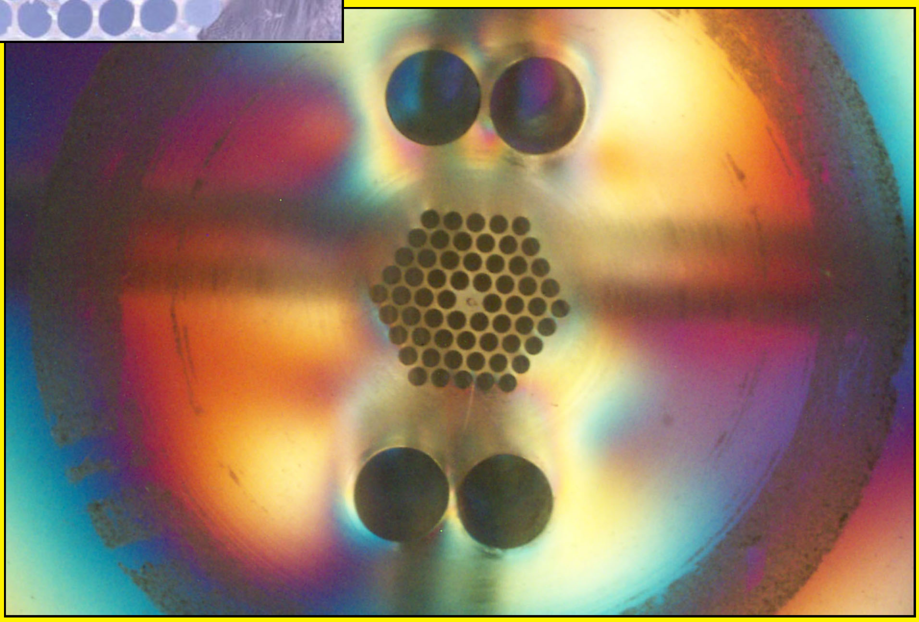
Australian Optical Society NEWS





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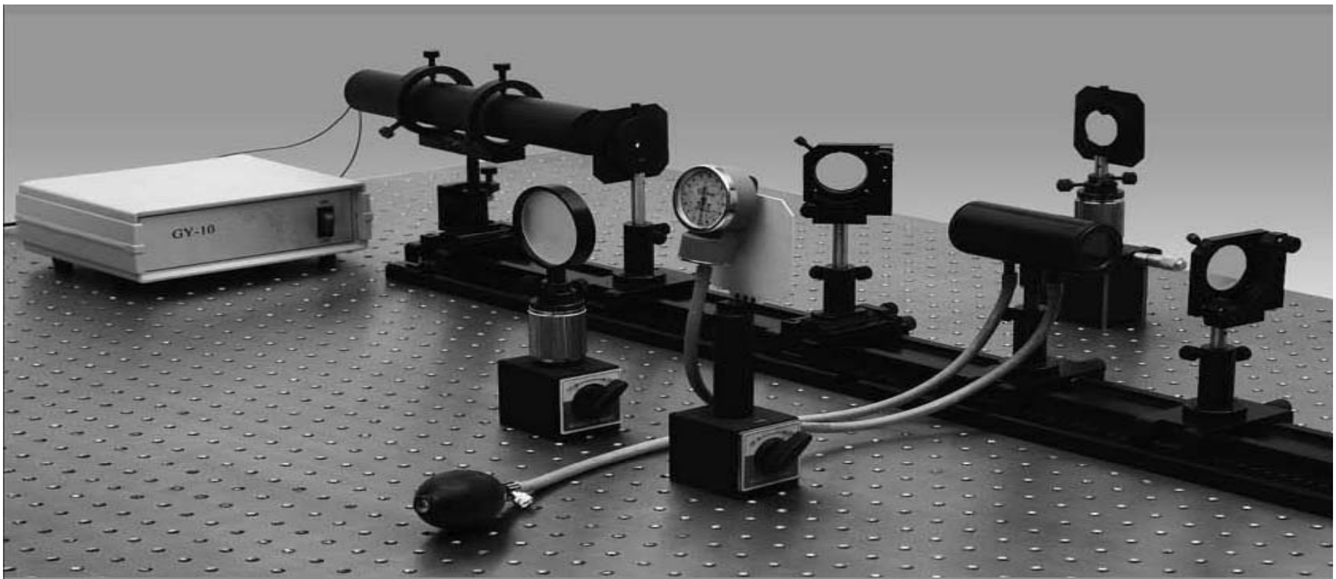
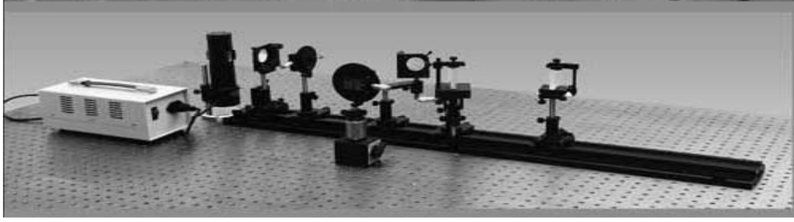
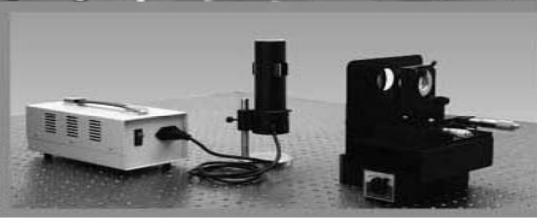
Model OEK-3 Optics Experiment Kit for General Physics Education







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19. Measure air refractive index
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AUSTRALIAN OPTICAL SOCIETY

ABN 63 009 548 387

AOS News is the official news magazine of the Australian Optical Society. Formed in 1983, the Society is a non-profit organisation for the advancement of optics in Australia. Membership is open to all persons contributing to, or interested in, optics in the widest sense. See the back page (or the AOS website) for details on joining the Society.

AOS News - Editorial Board

Submission guidelines

The *AOS News* is always looking for contributions, especially from AOS members. Here is a short summary of how to make a submission.

What can you submit?

* ***Scientific Article***
A scientific paper in any area of optics.

* ***Review Article***
Simply give a run down of the work conducted at your laboratory, or some aspect of this work.

* ***Conference Report***

* ***News Item***

* ***Book Review***

* ***Cartoon or drawing***

Reviewing of papers

On submission of a scientific or review article you may request that the paper be refereed, and if subsequently accepted it will be identified as a refereed paper in the contents page. The refereeing process will be the same as for any of the regular peer reviewed scientific journals. Please bear in mind that refereeing takes time and the article should therefore be submitted well in advance of the publication date.

How can you submit?

⏭ The easiest way is by email. We accept nearly all file formats. (Famous last words!).

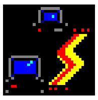
▸ Submitted articles will be imported into an Adobe Pagemaker file. It is best if the diagrams and other graphics are submitted as separate files. All common graphics formats are acceptable, but the resolution must be in excess of 300d.p.i.. Be aware that all colour diagrams will be rendered in grayscale, so if you do use colours, choose colours that show up well in grayscale.

▸ When using Greek letters and mathematical symbols, use font sets such as Symbol or MT Extra. Please avoid using symbols that are in Roman fonts, where the Option or Alt key is used; e.g. Opt-m in Times font on the Mac for the Greek letter mu.

▸ If using TeX, use a style file similar to that for Phys Rev. Letters (one column for the title, author and by-line, and two for the main body). The top and bottom margins must be at least 20mm and the side margins 25mm. Submit a pdf file with the diagrams included, as well as copies of the diagrams in their original format in separate files.

▸ If using a word processor, use a single column. If you do include the graphics in the main document, they should be placed in-line rather than with anchors, but must be submitted separately as well.

SUBMISSION OF COPY:
Contributions on any topic of interest to the Australian optics community are solicited, and should be sent to the editor, or a member of the editorial board. Use of electronic mail is strongly encouraged, although submission of hard copy together with a text file on floppy disk will be considered.



Where possible, diagrams should be contained within the document and sent as separate files. Figures on A4 paper will also be accepted. Note: all figures should be black & white or greyscale.

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Black and White in main body of newsletter - free to corporate members.
Conference announcements are free.

COPY DEADLINE
Copy for the next issue (Dec 05) should be with the editor no later than 21 November 2005.

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http://aos.physics.mq.edu.au

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SEPTEMBER 2005 **Volume 19 Number 3**

AOS NEWS

ARTICLES

Regular Articles

DEPARTMENTS

Cover Picture: End view of holey optical fibres; top left is a twin core fibre and bottom right is a fibre with holes for electrodes to be inserted for for poling the core. Photos supplied by Dr. Martijn van Eijkelenborg, Optical Fibre Technology Centre, University of Sydney.

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President's Report

The Annual General Meeting held at the BGPP/ACOFT conference in July apparently passed off very well - no thanks to me! I was stuck at a fog-bound airport in New Zealand. Ben Eggleton stepped in to chair the meeting at short notice - thanks Ben. At the meeting we had some change to the council. Steve Gibson has decided to step down from the council after several years of good service in helping to maintain our website and services. We have been very grateful for his services ... and the good news is that he's willing to keep performing that same function. Martijn de Sterke has been elected to replace Steve, so welcome Martijn.

Some of you may have noticed that the AOS website is being hosted on a new server (still at Macquarie University). This shift went very smoothly for which I am grateful, and this was in no small part due to Steve Gibson's diligence.

In the Queen's Birthday honours Rod Watkins, an AOS member, was awarded an AM for his work in promoting eyecare in the developing world. Rod is the founder of Scan Optics, an Adelaide based company that manufactures opthamological equipment that is designed to low-cost and rugged so that it is portable and can be operated in areas which don't have the infrastructure taken for granted in western cities. On behalf of all of the AOS I warmly congratulate Rod on this honour.

The AOS medal for 2005 has been awarded to Prof. Brian Orr - I would like here to offer my congratulations to Brian, who I'm sure will mark the occasion with an great talk at the ACOLS conference in December (in Rotorua). I urge you all to help make that conference a success.

The next conference after that will be the ACOFT conference in July 2006 in Melbourne, at which we may hold a one-day AOS meeting, much as happened in Canberra in 2004. As I write this, the AOS council is having an e-meeting to make a decision on this and other conference related matters. The e-meetings do not happen in real time, which is why I'm able to write this, but rather they run via email according to a protocol instituted by Keith Nugent when he was president. Anyway, as presaged by an earlier President's report, the main item off busineess in the current meeting is whether the AOS should take on 50% ownership of the ACOFT meetings, i.e. the 50% that was owned by the Photonics CRC before its demise. The timing, vis a vis this newsletter, is a little unfortunate but an announcement on the outcomes of this meeting, in particular whether there is an AOS meeting in July 2006, should be made by email about the time this goes in the post. After all 9 months is not a very long time to properly organise a conference from go to whoa, especially if youuu haven't any prior warning.

Below I've put a table that sets out the cost structure of the AOS News for those of you who are interested in seeing where at least some of their subscription is going. The data was chosen to illustrate the change in going from the old format to the new one with colour advertising.

Murray Hamilton
President, Australian Optical Society
August 2005

The table below sets out the budgeting figures for the newsletter (actual amounts to nearest multiple of $5, assuming 250 members). The circulation varies between 260 and 280.

	Expenditure	Advertising Income	cost to each member
Issue 3_ 2004			
Printing	850	0	
Postage	460		
Envelope stuffing	100		
Envelopes	100		
Copying	30		
	1540		6.16
Issue 2_2005		1750	
Printing	1580		
Postage	435		
Envelope stuffing	40		
Envelopes	100		
Copying	30		
	2185		1.74

Call for papers

Australasian Conference on Optics, Lasers and Spectroscopy 2005

ACOLS 2005

December 6–9, 2005

Royal Lakeside Novotel
Rotorua, New Zealand

This conference is the 7th in the ACOLS series, bringing together students and researchers working in all aspects of optics, lasers, and spectroscopy. It incorporates the 18th Australian Optical Society Conference, the 12th Australian Laser Conference, and the 22nd Australian Spectroscopy Conference.

Submissions are now invited for papers to be presented at ACOLS’05, for scientific and technical work that falls within, but are not limited to, the following topics (as outlined on the ACOLS’05 web page):

- Atomic and molecular spectroscopy
- Lasers and laser applications
- Optical imaging
- Optical fibres and photonics
- Atom optics and BEC
- Quantum optics, quantum information, and quantum computing
- Instrumentation and standards
- Biophotonics

One-page abstracts should be prepared according to the templates that can be downloaded from the ACOLS’05 web site and must be submitted electronically either through the web page or via email to acols05.submit@auckland.ac.nz no later than Friday September 9, 2005.

Abstract submission deadline: Friday September 9, 2005

Authors will be notified on the status of their submission no later than October 10, 2005

http://www.cce.auckland.ac.nz/conferences/index.cfm?S=CCE_ACOLS

Announcing

The New Zealand and Australian Quantum-Atom Optics Workshop

Queenstown ~ New Zealand, 29 November to 1 December, 2005

This international meeting, a satellite to ACOLS 05 (Rotorua, NZ, 6 – 9 December), will feature prominent international and local speakers.

Early expressions of interest are requested: number of participants may need to be limited due to facility size.

Jointly hosted by the Australian Research Council Centre of Excellence for Quantum-Atom Optics (ACQAO), and its New Zealand partners.

Workshop chair: Professor Rob Ballagh, University of Otago

Further information is available at:
www.physics.otago.ac.nz/uca/conference

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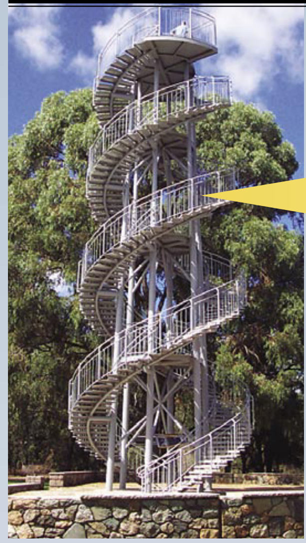


Focus on Microscopy 2006

Sunday 9th - Wednesday 12th April 2006
Perth, Western Australia

www.FocusOnMicroscopy.org

Focus on Microscopy 2006 is the continuation of a successful conference series presenting the latest innovations in optical microscopy and its applications in biology, medicine, material science, and information storage. 3D optical imaging and related theory are important subjects for the conference. The series is as relevant now as at any time in its history as the scientific and engineering communities strive to meet the needs of a surging life sciences sector as well as respond to the sustained pressure on miniaturisation in lithography and data storage.

The 2006 meeting will be held in Perth on Australia's western seaboard. The conference will be held in the nearby port city of Fremantle, at the scenic Esplanade hotel, close to the boat harbour and Perth's famous beaches. Perth's relaxed and outdoor lifestyle should prove an ideal setting for a stimulating and enjoyable meeting – see you there!

Dead-line for submission of abstracts will be 9 January, 2006.

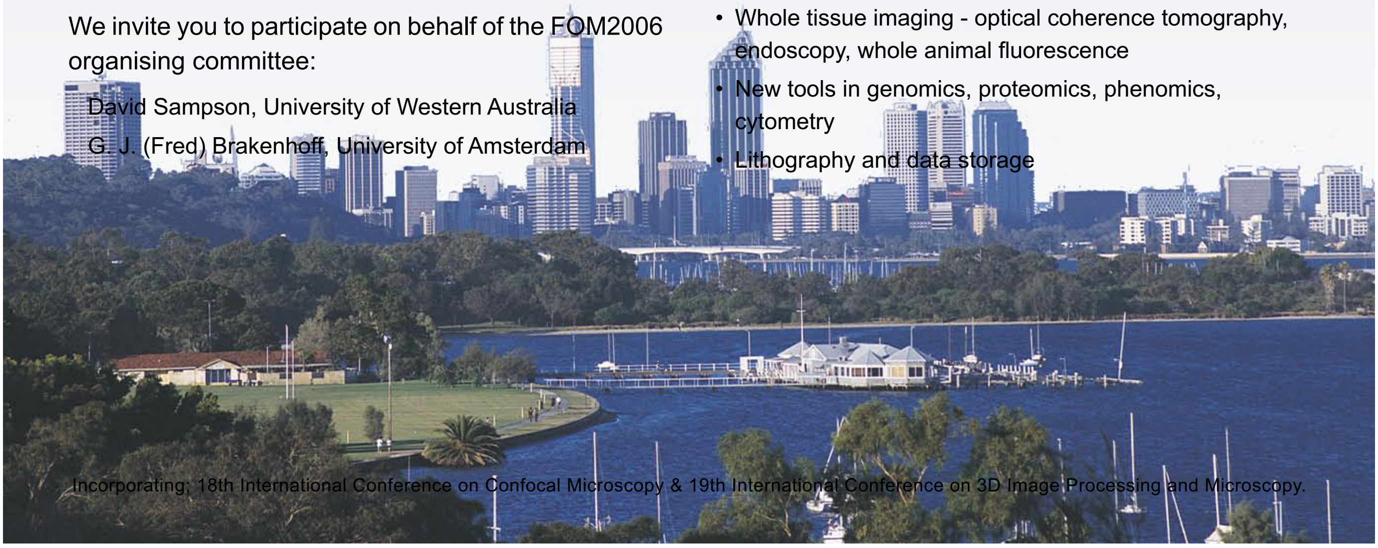
We invite you to participate on behalf of the FOM2006 organising committee:

David Sampson, University of Western Australia

G. J. (Fred) Brakenhoff, University of Amsterdam

Conference topics include:

- Confocal and multiphoton-excitation microscopies
- Novel illumination and detection strategies – selective-plane, extended depth of focus, 4pi, structured illumination
- Fluorescence – new labels, fluorescent proteins, quantum dots, single molecule, excitation-emission spectroscopy
- Time-resolved fluorescence – FRET, FRAP, FLIM, FCS
- Coherent non-linear microscopies – SHG, THG, SFG, CARS
- Scattering processes: Raman, light scattering spectroscopy, second harmonic
- Multi-dimensional imaging
- Sub-wavelength resolution – near field microscopy, total internal reflection
- Laser manipulation, ablation and microdissection, photoactivation
- Magnetic resonance and X-ray microscopy
- Image processing and visualisation
- Live cell and tissue imaging
- Whole tissue imaging - optical coherence tomography, endoscopy, whole animal fluorescence
- New tools in genomics, proteomics, phenomics, cytometry
- Lithography and data storage



Incorporating; 18th International Conference on Confocal Microscopy & 19th International Conference on 3D Image Processing and Microscopy.

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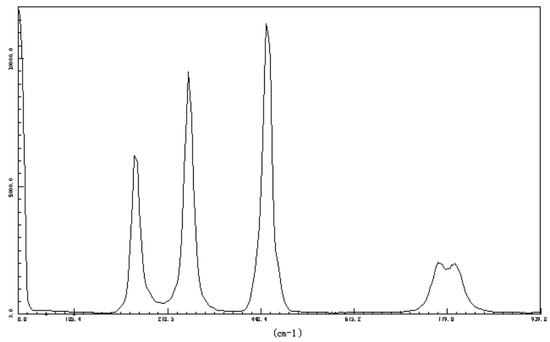
RA-300 Laser Raman Spectrometer



Raman spectrum of CCl_4 with notch filter used

RA-300 Laser Raman Spectrometer is used for Raman spectrum and fluorescence measurement in physics and chemistry labs of universities and research institutions. It offers a powerful non-destructive method of sample analysis

FEATURES

- Computer interfaced
- High resolution
- Low stray light
- Single-photon counter detector
- High stable external optical path
- Various accessories
- Adoption of notch filter

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Range	300 ~ 650nm
Accuracy	≤ ± 0.4nm
Repeatability	≤ 0.2nm
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Slit width	0 ~ 2mm, adjustable
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Scan Optics

Rod Watkins, Scan Optics, Thebarton, SA5031

Perhaps the most interesting thing about Scan Optics is that the company was set up to make a product that had no potential use in Australia, and its use outside Australia required fundamental changes to one of the most common surgical procedures in the world. Few business consultants would think that was an outstanding recipe for success. Eighteen years later, however, the company has supplied equipment to more than 120 countries, more than 600,000 cataract operations are carried out each year using Scan Optics equipment, and the company has been named twice in the past four years among the top ten companies in the Deloitte Technology Fast 50 Awards.

Scan Optics was incorporated in 1987. At that time the surgical procedure for cataracts was vastly different in Australia and the developed world to that commonly carried out in the non-industrialised world.

Cataracts and cataract surgery

Around the world there are 50 million people who are blind. Of these, 90 percent live in developing countries and about half are blind because of cataracts. Any effort to reduce global blindness must therefore be directed in the first instance towards reducing cataract blindness in developing countries.

Cataracts are formed when the biochemistry of the crystalline lens of the eye is altered, fluid droplets which scatter light are formed in the lens, and the lens loses transparency. The triggers to cataract formation include ultraviolet radiation, diet, dehydration, trauma, smoking, and various drugs. Most of these are more prevalent in developing countries, where the onset of cataracts is typically a decade or more earlier than in developed countries. The high prevalence of cataract blindness in developing countries, however, is largely due to a lack of resources to treat people who are blind.

The oldest treatment for cataract, known as “couching”, has been used for at least 1,500 years. In this procedure, the opaque lens is dislocated either by a blow to the outside of the eye from a pointed object, or by inserting a sharp thorn through the eyeball and physically dislodging the lens. Couching is still carried out by traditional doctors in Africa and in China, but in most of the world the opaque material of the lens is removed surgically. This is a relatively straightforward procedure. The critical issue is how the refractive power of the lens is to be replaced in order to provide clear vision.

The simplest surgical treatment, known as “intra-capsular cataract extraction” or ICCE involves making a large incision in the eye (up to 12mm long) and removing the lens intact. The refractive power is then replaced by a spectacle lens of high positive power, about +12 dioptres. This procedure can be carried out quickly and needs no expensive equipment or consumables, but the improvement to the quality of life of the patient is limited. The surgical incision often causes large, and changing, corneal astigmatism as the scar tissue contracts. The spectacle lens magnifies the retinal image and so distorts the visual space of the wearer, reduces the field of view, produces a peripheral blind area between the field seen through the spectacle lens and that seen outside the lens and needs to be changed several times to allow for the changing astigmatism, and the lenses are heavy and unsightly.

This surgical technique was replaced in developed countries during the 1970s by “extra-capsular cataract extraction” or ECCE. The crystalline lens is sometimes compared to an avocado, with a hard nucleus, a soft cortex and a fibrous capsule. In ECCE the nucleus of the lens is removed and the cortex is aspirated, leaving the capsule intact. This procedure can be carried out through a smaller incision, so reducing the corneal astigmatism. The mechanical support of the capsule for the vitreous humor is also retained. ECCE is usually accompanied by implantation of a rigid intraocular lens (IOL) made from polymethyl methacrylate, which is placed inside the capsule to replace the lens refractive power. This overcomes the optical and cosmetic disadvantages of spectacle lens correction.

(In fact ECCE has now been almost completely replaced in Australia and other developed countries by a small-incision procedure known as “phacoemulsification”. An incision of 3mm or less is made, an ultrasonic probe is inserted which chops and emulsifies the hard nucleus of the lens, the contents of the lens are removed with an irrigation/aspiration device, and a rolled up silicone IOL is inserted through the incision and unrolled inside the eye. No sutures are used. The next wave of technology seems likely to come from work now in progress to develop an IOL and a surgical procedure in which the accommodative function of the crystalline lens is replicated.)

In 1987 when Scan Optics was incorporated, ECCE was the preferred procedure in Australia but there were many obstacles to its adoption in developing countries. The procedure must be carried out while the surgeon is looking through a microscope, and surgical microscopes were either too expensive or of insufficient quality and were inappropriately designed for the conditions of surgery common in developing countries. IOLs cost around A$350 and other consumables cost another $150. The ECCE surgical procedure took 45 minutes, while the ICCE procedure took less than ten minutes. The result was that ICCE remained the standard surgical procedure for the vast majority of cataract-blind people in developing countries.

The company formation

My own educational background at the time included a master's degree in optometry, the postgraduate optics course at Imperial College, and a Ph.D. in physics (on the optics of the human eye). My first employment was teaching optics to optometry students, and I had spent the next 14 years in the optical industry working in ophthalmic optics and defence optics. During this time, friends in the Department of Ophthalmology at Flinders University discussed with me the possibility of making an ophthalmic surgical microscope that was appropriate for developing countries.

There are some broad constraints in the design of microscopes to be used for eye surgery. They are used at low magnification, sometimes as low as 3.5x in order to provide a high depth of field to avoid the need for refocusing from the cornea to the posterior lens surface, and rarely at more than 8x. The working distance is long, about 180mm, to allow for surgical instruments in the working area. An essential requirement is a very high light level which is coaxial with the viewing system. The posterior capsule of the lens must be completely cleaned, or "polished", to prevent regrowth of opaque tissue and the capsule is best seen by backscattered light. Ophthalmic microscopes usually provide an illuminance of about 80,000 lux in the plane of the patient's eye, and sometimes up to 150,000 lux; this compares with about 150 lux for normal room lighting. Lighting is often provided by a 150 watt halogen lamp focused on a fibre optic bundle and directed at the eye, and is usually delivered by a prism close to the microscope objective rather than by a beam splitter, to avoid the light losses of a beam splitter arrangement. Microscopes used in countries like Australia are usually large, weighing up to 180kg, and sometimes are fixed to the ceiling of the operating room. They commonly have foot controls for focusing, magnification change, translation in the horizontal plane and light intensity so the surgeon's sterility is not compromised and the hands are free to hold instruments. The cost of ophthalmic microscopes in major hospitals is $50,000 to $100,000.

For an ophthalmic microscope to be appropriate for developing countries, there were a number of unique requirements. In those countries, typically 80% of the population lives in rural areas outside the major centres and eye care must be delivered through many smaller regional hospitals and clinics. The microscope had to be capable of being easily carried by aircraft, car, or boat. It had to be light weight, well packaged and robust for transport. Most surgical microscopes are kept in air conditioned operating rooms, but this one had to be protected against mould, corrosion and dust in environments ranging from deserts to humid tropics. It had to be capable of working from mains power of uncertain reliability, or from a car or motor cycle battery. It had to be easily serviced and maintained by staff with minimal training or technical skills. Finally, this had to be achieved at a cost that was affordable to rural hospitals, individual ophthalmologists and aid

Fig 1. Eye surgery in a refugee camp in Uganda.

organizations. The goal was to keep the price below US$6,000.

An Industrial R&D Grant of $40,000 supported the project during the two-and-a-half years from concept through design, prototype manufacture, evaluation and redesign to the first sales. It was decided at the outset to concentrate on the core features of image quality and lighting and to strip away everything non-essential. Friends were called on to help with mechanical and electronic design. The Department of Ophthalmology at Flinders University helped with the specifications, with evaluation and clinical trials and with ongoing advice. The optical design for the viewing system was severely limited by the price target and the small volume needed for prototype work. A range of designs was considered, including a rather strange biocular catadioptric system. In the end it was decided that the only cost-effective solution was to adapt an existing commercially available optical system. Binoculars, various ophthalmic devices and a great many laboratory microscopes were considered. Eventually the first model was based on a laboratory microscope from Nikon, chosen for its resolution, field of view and depth of field, which was then modified both optically and mechanically. (For many years now however Scan Optics microscope viewing systems have been based on Olympus optics, and the company has received great support from Olympus both in Australia and in Japan.) The challenge of the lighting system was to provide highly coaxial lighting, and a sufficient amount of light for the surgeon while still having the capability of being powered from a 12 volt battery. The lighting optics comprising lenses, mirrors, prisms and filters have been obtained at different times from Australia, the United States and Asia.

Fig 2. The first Scan Optics microscope model, clamped to an instrument trolley.

The microscope that was first developed clamps directly to the operating table, at the patient's shoulder. It was made from machinable plastic and non-ferrous metal, and packed into an aluminium case the size of a suitcase. The power supply was designed so that if the mains power failed, a 12 volt battery would cut in automatically.

Field trials were carried out in Australia and Indonesia, the microscope was displayed for the first time at the International Congress of Ophthalmology in Singapore in 1990, and the first sales were made into Indonesia. Although this model microscope is still in production, none of the original unit remains. Scan Optics has a policy of continuous product improvement, and over the years all mechanical, optical and electronic components have been changed.

Scan Optics today

Scan Optics developed a close relationship with non-government organizations working in the field of prevention of blindness in the United States, Australia, the United Kingdom and Europe. In the early 1990s several of these were trying to make modern ECCE cataract surgery practical for developing countries. In particular CBMI (Christian Blind Mission International) in Germany and Australia, which supports programmes in more than 100 countries, was developing a strategy for providing the human resources and equipment infrastructure needed. The Seva Foundation in the United States and The Fred Hollows Foundation in Australia were working on methods to reduce the cost of IOLs and consumables, and the time to carry out the surgery. ECCE slowly became the procedure of choice, and Scan Optics made the most appropriate microscope.

The early years of a new medical equipment company can be difficult, as peer recommendation is important and potential users often want to see the company and the product often enough to be confident that the company will survive into the future. Scan Optics was significantly helped in 1993 when it won an international tender to supply 100 surgical microscopes to The Fred Hollows Foundation to support its programme in Vietnam. This allowed investment in manufacturing equipment and in people and put enough microscopes into the field that peer recommendation became possible. (Today, more than 250 hospitals in Vietnam have eye units which use Scan Optics microscopes.)

As the company grew, many requests were received to modify and develop equipment for other medical disciplines and for industrial applications. This forced a formal review of the business of the company. The view was taken that it was more difficult and expensive to sell existing products into new international markets than to develop new products for known markets. We decided that our business is primarily optics, that our market is medical equipment, that our social responsibility is towards underprivileged people, and that our commercial success depends on providing an exceptional standard of price, quality and service. The mission statement of the company says "Scan Optics manufactures medical equipment to help reduce preventable suffering throughout the world. We are a company concerned with people, and we are committed to quality in all aspects of our business."

The International Agency for the Prevention of Blindness, which is the World Health Organisation and non-government organisation umbrella that manages global blindness, says that for eye care to be effective it must not only be appropriate for the circumstances under which it is delivered and affordable but it must also be accessible. To design and make a piece of equipment that meets a need, and at an acceptable price, is not enough; in fact, those are just necessary starting points. A successful supplier of eye care for developing countries must also have a plan for making potential users, who are often in remote locations around the world, aware of its existence. End users often need to be helped to access local or international sources of funds. The supplier must work out how it will be paid from countries that may have a non-tradeable domestic currency and very tight controls on the export of hard currency. It needs to be able to get equipment through customs in countries where that can be notoriously difficult and delivered by local transport to a rural hospital. Finally, there must be a programme for service and maintenance and a way of keeping the equipment operating for many years into the future, usually with limited access to trained technical staff. The success of Scan Optics has been largely due to the fact that the company has concentrated on doing these things well.

It is essential to stay in regular contact with existing and potential users of equipment. This is done by attending professional conferences in many countries, advertising in professional journals, and regular direct mail newsletters. International recognition is difficult for a new company as the cost can be very high; the largest ophthalmic companies spend several millions of dollars on a three and a half day international conference.

In the last financial year Scan Optics shipped equipment to 76 countries. The most important of these was China which is supported by a company sales office in Shanghai. It is perhaps of interest that Nigeria, which has the reputation of being one of the most difficult countries to trade with, was fourth most important.

The product range now includes three models of ophthalmic microscope and an ORL (ear, nose and throat) microscope, two models of surgical light and instruments for examining eyes. The most advanced model, the SO-5800 microscope has foot controls for focus, zoom and horizontal translation, a secondary microscope for training purposes, and a coaxial video camera and monitor so that others in the operating room can follow the procedure. The company has quality certification to ISO9001, which includes product design, and various products have national and international medical approvals including from the US Food and Drug Administration. As the products are portable and robust, they are commonly used by defence forces and some have NATO classification.

Scan Optics has always been associated with a university. In the early years the company was located in the research park of the University of South Australia when it was the only university-based park in the state. When Flinders University established its own park, Scan Optics was one of the first tenants and relations with the Department of Ophthalmology, the Department of Physics and the Biomedical Engineering Department were all important. The company is now located at the University of Adelaide Commerce and Research Precinct.

The future

Research and development is vital to the future. At any time, about one third of sales revenue is generated by new products that have been released within the past three years. Internal R&D capabilities include optical design, electronics, engineering and instrument design, and industrial design. Software development is contracted.

Optical design in the company has changed substantially over the past few years. Relatively little prototype manufacture is now carried out. The interaction between optical design software and mechanical design CAD software with the ability to export and import directly between the two allows the end function of quite complex systems to be modeled in detail by computer. Instruments that previously might have been through several prototype iterations now usually have only one prototype version, and sometimes it is possible to go directly to a commercial instrument without a prototype stage at all.

The advent of non-sequential optics has also had a major impact. In non-sequential systems, the optical space does not consist of the usual linear optical train of sequential surfaces but of solid objects placed in three-dimensional space. Rays can travel from any

Fig 3. The SO-5800 model microscope.

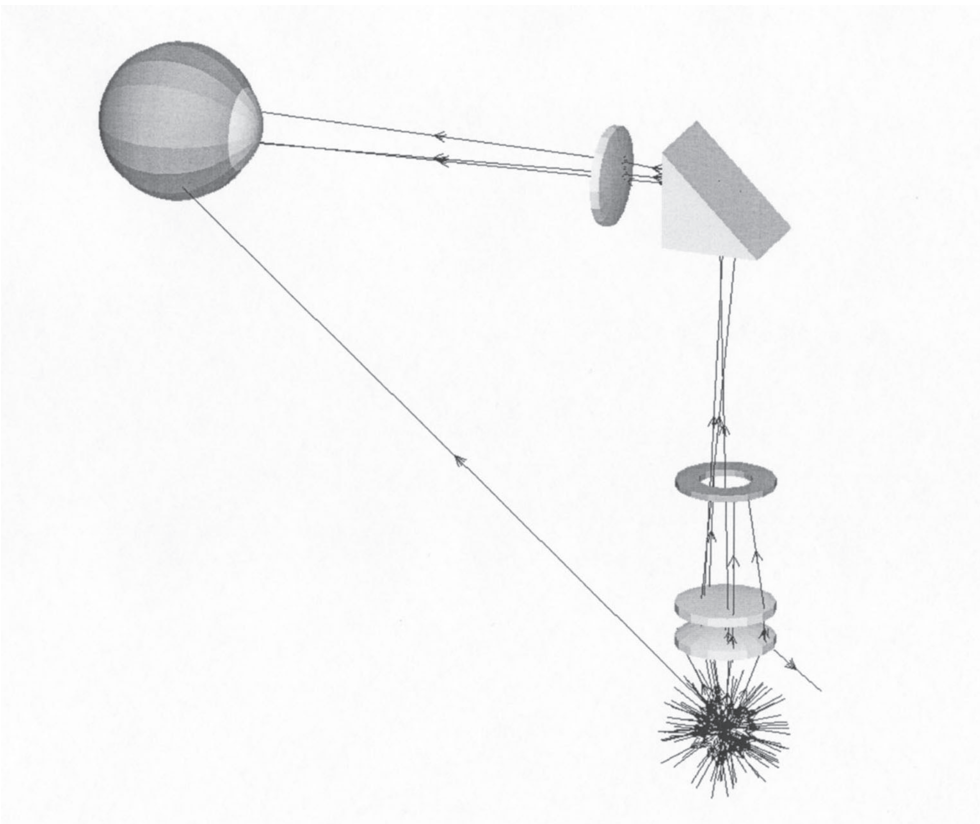


Fig 4. A non-seqential system comprising a filament light source, lenses, an aperture, a prism and a model eye.

object to any other object, in any sequence. The edges of lenses are equally as valid optical surfaces as the refracting surfaces. Absorption and scattering can be modeled reasonably accurately, so it is possible to import mechanical components such as anodized or painted lens cells into the optical system and to treat them as optical components. In ophthalmic instrument design, the ability to model the eye as a solid non-sequential system means that the model can include localized absorption to simulate cataracts or vitreous inhomogeneities, and the cornea and lens surfaces and media can scatter light. The retina can be an absorbing detector in order to investigate light distribution, although the number of pixels has a significant effect on the speed of computation. (In our model the retinal detector subtends 50 degrees and has 100 annular by 100 radial pixels.)

Finally, the set-up times for computer-controlled CNC machines (lathes and mills) have been greatly reduced by software that converts CAD design into machine language, and this makes it practical to design complex shapes such as prism cells in metal or machinable plastic and to make them accurately and cost effectively in small volume. This has greatly increased the flexibility of design choices for both optical and mechanical systems.

Typically, the design sequence now is to model imaging optical systems using sequential optics and lighting systems using non-sequential optics. The version that is then exported to the CAD package is usually non-sequential, as the solid objects are represented more accurately, and metal cells and housings are added. The complete system is then re-evaluated in the optical design package. When the design is finalized, the CAD components are exported to the software package that generates machine language code.

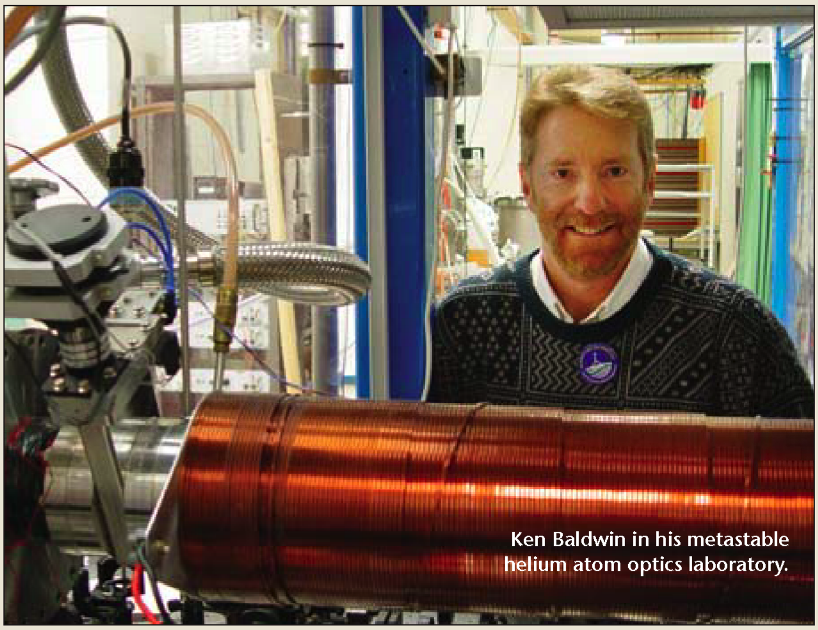
In the past year, Scan Optics has developed to full commercialisation a binocular indirect ophthalmoscope for examination of the retina and a slit illuminator for use with an excimer refractive laser. Products in development include a portable retinal camera with an 8MP sensor, and a new generation of surgical microscope.

Blindness is different both quantitatively and qualitatively to most other medical conditions. The loss of quality of life that blindness brings is matched by few other medical problems. The methods of prevention, diagnosis and treatment of the major causes of global blindness are generally well understood, but adequate resources are a major limitation. Scan Optics expects to continue to contribute to the effort to reduce global blindness by developing technology that is appropriate, affordable and accessible.

(Rod Watkins was awarded the AM in the 2005 Queen's Birthday Honours list for his work in bringing eye-care to the developing world. Ed.)

Optics in Australia

Ken Baldwin and Benjamin J. Eggleton



Ken Baldwin in his metastable helium atom optics laboratory.

Australia is renowned for its abundant sunlight, which enhances the vibrant colors of the continent—from its red deserts to the rainbow-colored fish of the Barrier Reef. In the scientific realm, Australia is also well known for its outstanding contributions to the study and application of light in science and engineering. This article presents a brief overview of Australian optics research and recent highlights.

Optical and quantum optical science are national research strengths in Australia, and the country has a substantial history of achievement in these fields. Optics was made a national research priority area between 1995 and 1997 through the Australian Research Council (ARC—the equivalent of the National Science Foundation in the United States). The field was also a cornerstone of the Photon Science and Technology priority area established by the Australian Government to guide research directions from 2001 to 2002.

One indicator of Australia's success is the number of major international optics conferences that were held there in recent years, including:

- The 14th International Conference on Vacuum Ultraviolet Radiation Physics, Cairns, 2004
- The 16th International Conference on Laser Spectroscopy, Cairns, 2003
- The 6th OptoElectronics and Communications Conference/ Integrated Optics and Optical Fibre Communication Conference, Sydney, 2001

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Photo by Tim Wetherell

- The 3rd Asia-Pacific Conference on Communications, Sydney, 1997
- The International Quantum Electronics conference, Sydney, 1996.

Most recently, Australia has been selected to host the International Commission for Optics Congress in Sydney in 2008.

Australia is particularly strong in the study of the behavior of atoms and photons at the quantum level, and the control of light for quantum computing and optical communications. In fact, in 2003 three ARC Centres of Excellence were established in these areas:

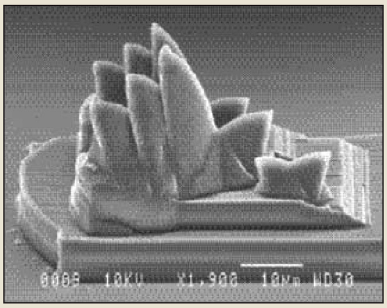
- The Centre for Quantum-Atom Optics[1]
- The Centre for Quantum Computing Technology[2]
- The Centre for Ultrahigh Bandwidth Devices and Optical Systems.[3]

Centres of Excellence play an important role in Australian scientific research. Only eight of them were established nationwide—a fact that demonstrates the pre-eminence of optics research in Australia. (Of the remainder, one was in the related field of solar photovoltaics). The Centres complement three existing research organizations that emphasize optics applications and commercialization–the Australian Photonics Cooperative Research Centre,[4] the Centre for Lasers and Applications[5] and the Australian Consortium for Interferometric Gravitational Astronomy.[6] There are also a large number of smaller optics research groups.[7–17]

Indeed, research in Australia now spans almost the entire field of optics. This will soon be enhanced by the opening of the Australian Synchrotron in 2007.[18] The Australian Optical Society (AOS) provides a network for these groups and centers, which come together at the various AOS-sponsored meetings. The AOS has reviewed and highlighted Australia's strength in optics in a 1994 report.[19]

Building on 20th Century foundations

Optics in Australia expanded rapidly during World War II, when a complete manufacturing industry was established to produce optical munitions. The skill base that was formed to meet the pressing national defense need led to the



Micrograph of the Sydney Opera House laser-fabricated in polymer at the CUDOS laboratory in SUT. [From M. Straub et al., Opt. Mater., **27**, 359-64, (2004).]

Ben Eggleton in the CUDOS laboratories investigating ultra-fast pulse propagation in photonic crystal fibers.

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formation of a number of optical manufacturing companies, and sparked the establishment of research groups in universities and government research labs.

Two key figures in Australian optics emerged during the immediate post-war period: W.H. ("Beattie") Steel and Sir Alan Walsh. Both worked for the government research laboratories of the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Steel made major contributions to the theory of image formation and to interferometry, while Walsh developed the atomic absorption spectrometer—which created an industry whose market today exceeds $500 million per year.

Astronomy has been a key driver of innovation in Australian optics. The Anglo-Australian Observatory (Ben Gascoigne), the Intensity Interferometer (Hanbury Brown) and the CSIRO Solar Observatory (Ron Giovanelli) were unique instruments that helped put Australia at the international forefront of astronomy and drove a wealth of optical research programs.

This technology base placed CSIRO as a leading innovator in specialist optics manufacture,[8] including ion-assisted deposition techniques, teflon polishing for flat surfaces and phase shifting interferometry for precision measurement of optical surfaces (such as pioneered by Parameswaran Hariharan). The most recent contribution is the polishing of the test masses for the Laser Interferometer Gravitational-wave Observatory (LIGO) and precision optical components for the Jet Propulsion Laboratory.

Over time, Australian optics diversified, after having been founded on a strong classical optics base through contributors such as Hans Buchdahl. Neutron optics techniques were pioneered by Tony Klein and Geoff Opat starting in the 1970s and contributed to the development of atom optics in Australia. Strong connections with Dan Walls and Crispin Gardiner in New Zealand led to rapid growth in quantum optics on both sides of the Tasman sea. Other New Zealand contributors in optics and lasers, including Jack Dodd and Wes Sandle, also stimulated growth in Australian activity in lasers and other areas of optics.

Katja Lyytikainen operating the OFTC fiber draw tower in the APCRC.

Australia was an early player in the development of fiber optic communications—which was catalyzed by the work of Tony Karbowiak in the mid-1960s with support from the Australian telecommunications industry. This area mushroomed both academically and commercially following the widespread adoption of fibers in the Australian telephone network by the early 1980s.

Australian Photonics Cooperative Research Centre

Building on Australia's widespread expertise in optical fiber technology, the government established the Australian Photonics Cooperative Research Centre (CRC) in 1992 to synergize the activities of the many organizations involved in photonics. It is one of the largest of about 60 CRCs, which are part of a government initiative to build partnerships between the public and private sector, particularly to assist in building Australia's high technology industry.

The Australian Photonics CRC includes five universities: The Australian National University (ANU), the University of Sydney, the University of Melbourne, the University of New South Wales and the Royal Melbourne Institute of Technology University. Government labs and industry partners, ranging from small startups to transnational companies, are also part of the CRC. The Centre is in its 13th year and has about 300 participating staff and students.

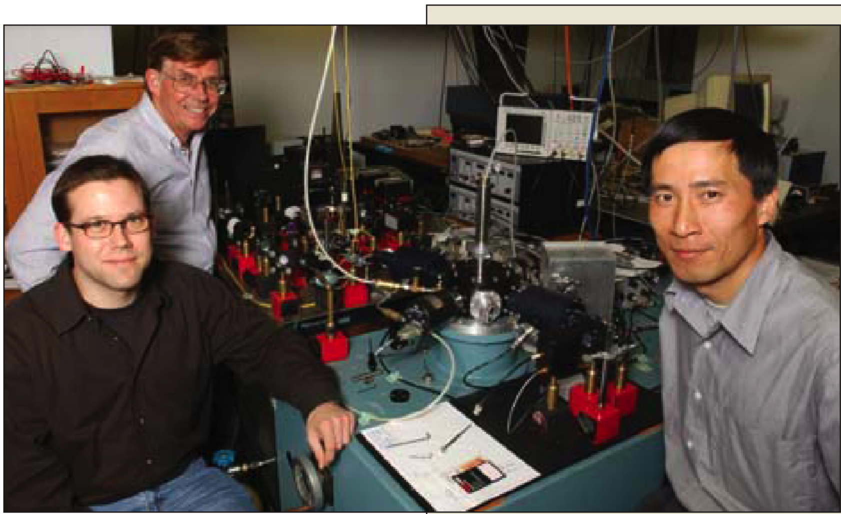
The CRC has major research capabilities in specialty fiber, fiber devices, telecommunications technologies and sensor systems. The CRC has focused these capabilities into four major "Challenge Projects": fiber to the premises, long haul systems impairment mitigation, transponders for coarse wavelength division multiplexing (CWDM) and defense and distributed sensing systems.

The CRC program places a strong emphasis on commercialization and is widely regarded as successful in this respect; it has spun-off about 15 photonics companies, including some that have progressed to become global market leaders. These companies span the technology of photonics from fiber to advanced CWDM equipment for metropolitan area networks, and are based in Australia, The United States, China and Germany.

Centre for Lasers and Applications

Established in 1988 as an ARC special research center, the Centre for Lasers and Applications (CLA) is located at Macquarie University in Sydney. Its emphasis on laser applications is based on the fundamentals of optics, electronics, physics, chemistry and biology. The CLA's longstanding research on high-power metal-vapor lasers has been extended to solid-state lasers (e.g., those based on novel crystals), optical fiber lasers and nonlinear-optical wavelength conversion (e.g., Raman lasers and narrowband tunable optical parametric oscillators).

The Centre's advanced laser-micromachining services have produced precision orifices for Olympic torches, laser-scribed coding of machine parts



(*Left to right*) Florian Englich, Brian Orr (CLA Director) and Yabai He with a continuous-wave cavity ringdown spectrometer for multiwavelength molecular sensing.

and new photonic crystal devices (among the CLA's CUDOS-related activities).

Other CLA success stories include the "Magic Wand"—a compact, solid-state Raman laser system that delivers coherent yellow light for ophthalmology, dermatology and treatment of blood vessels. In other medical applications, the CLA has developed laser-cured protein solder for microsurgical repair, short-pulse laser treatment of teeth and breath-test diagnostics by rapidly swept cavity ringdown spectroscopy.

Innovative flow cytometry techniques developed at the CLA use high-repetition-rate pulsed lasers or lamps to identify and enumerate pathogenic microorganisms. CLA research also includes fluorescence-based microscopy.

Australian Consortium for Interferometric Gravitational Astronomy

The Australian Consortium for Interferometric Gravitational Astronomy (ACIGA) has a research and development program aimed at improving the performance of laser interferometer gravitational wave detectors to reach the limits set by mechanics, quantum mechanics, lasers and optics. The Consortium is applying this knowledge to develop methods to improve the performance of current detectors to the level where gravitational wave events should be regularly recorded. It is establishing the capability to build the southern hemisphere component of the worldwide observational network—which will be internationally funded—once the angular resolution of the existing network becomes a major limiting factor.

(a) Installation of suspended test masses at (b) the Gingin test facility.

The consortium comprises the following institutions:

- The ANU, where researchers are working on advanced interferometer configurations and control systems, quantum optics and data analysis;
- The University of Western Australia, which houses efforts to study suspensions and isolation systems, develop sapphire test mass development and conduct source modeling;
- The University of Adelaide, which specializes in injection locking, high power laser development and wave front distortions; and
- Monash University, where investigators are making gravitational wave form calculations.

The CSIRO Space Optics Group is an affiliate member. The ACIGA universities operate a facility at Gingin in Western Australia (see photos at left). This facility can house a suspended interferometer that is 80 meters in length. Initial research is focused on diagnosing the operation of a high power optical system (on the order of 1 MW circulating power).

ACIGA actively collaborates with groups conducting international projects, including the U.S. LIGO Project, the French Italian VIRGO project, the British German GEO Project and TAMA in Japan.

Centre for Quantum Computing Technology

A multi-university collaboration, the Centre for Quantum Computing Technology (CQCT) undertakes research on the fundamental physics and technology involved in building, at the atomic level, a solid-state quantum computer in silicon. There are two optics programs in the Centre, both at the University of Queensland (UQ).

The aim of the linear optics program is to construct the basic building blocks for an optical quantum processor

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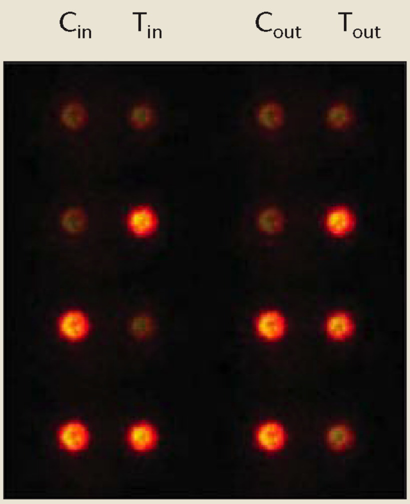
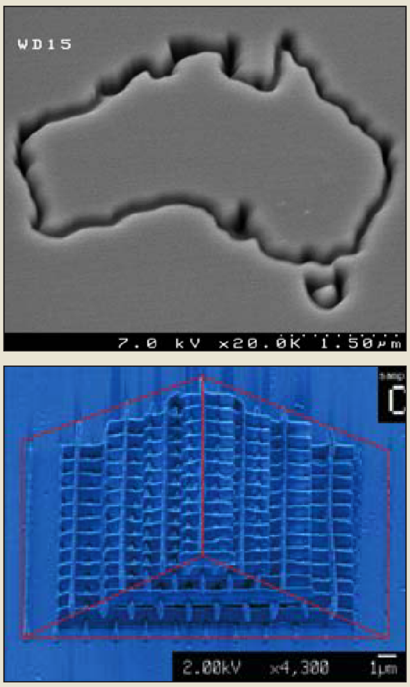
focusing on the two-qubit controlled-not (CNOT) gate and to develop the foundation for a scalable architecture. The strategy involves both experimental and theoretical research into how to: 1) develop measurement techniques for characterizing the relevant quantum states and processes; 2) improve photon sources and optical circuitry performance; 3) create and apply measures of gate performance; and 4) realize simple quantum circuits.

Through the quantum dot program, investigators aim to develop a hybrid electro-optical quantum gate technology whereby the nonlinear interaction required for quantum gate operation is provided by a strong cavity quantum electrodynamical interaction between a single photon and a quantum dot. The use of nanocrystal quantum dots and fused silica microcavities allows for potentially scalable technology, as well as a possible "bridging" technology between optical and electronic quantum circuits.



CQCT linear optics CNOT gate truth table. Left column pairs are ideal input qubits (dim = 0, bright = 1) used to generate control and target qubits in the experiment (right column pairs).



(*Top*) Micron scale map of Australia viewed at 45 degrees, fabricated at the ANU CUDOS node with a focused ion beam on an ultrafast pulsed-laser deposited chalcogenide glass film. (*Bottom*) Prism woodpile device, laser-fabricated in polymer by the SUT CUDOS group.

The Centre for Ultrahigh Bandwidth Devices and Optical Systems

The mission of the Centre for Ultrahigh Bandwidth Devices and Optical Systems (CUDOS) is to demonstrate all-optical processing applications and devices that will enable next-generation optical communication systems by drawing on research into non-linear optical materials, photonic crystals, micro-structured optical fibres and micro-photonics. Headquartered at the University of Sydney, CUDOS includes research groups at the ANU, Macquarie University, Swinburne University of Technology (SUT) and the University of Technology Sydney.

Research at CUDOS focuses on two major areas: micro-photonics and non-linear photonics. Investigators hope to achieve ultrahigh-speed all-optical signal processing on a single photonic chip by using knowledge in these two areas to develop micron-scale photonic components incorporating nonlinear photonics processes. Light is coupled to the chip from sophisticated optical fibers, including microstructured fibers. The Centre is initially focused on creating the building blocks for this photonic chip.

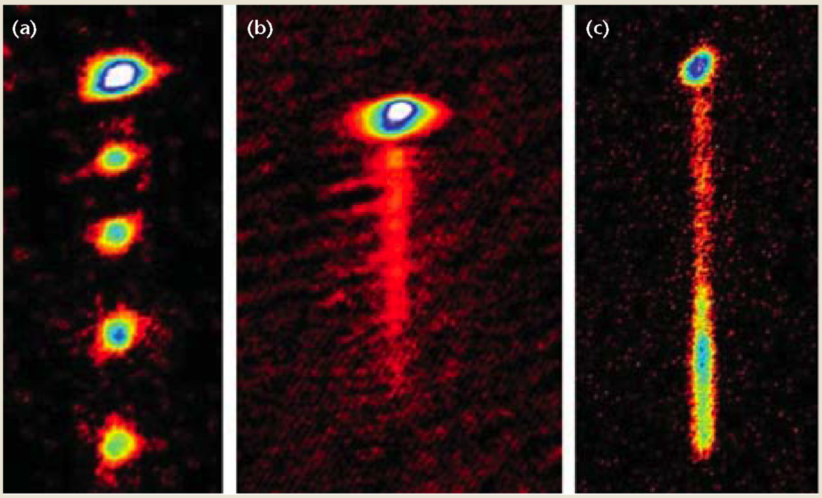
Central to this vision are photonic bandgap materials because of their potential for miniaturization and their highly nonlinear optical response function. A large part of the CUDOS program is therefore devoted to studies of their fundamental properties, ways to fabricate them and applications of these materials to new optical technologies. Centre researchers are studying one, two and three dimensional photonic bandgap structures in a range of different materials and have a strong interest in the nonlinear optical properties of these materials.

The Centre for Quantum-Atom Optics

The fields of quantum optics and atom optics are brought together at the Centre for Quantum-Atom Optics (ACQAO), where scientists aim to understand and exploit the quantum nature of multiple-particle states—whether they be atoms, photons or both. Building on Australia's strong history of research in quantum optics, ACQAO's goal is to study fundamental quantum effects, such as optical entanglement for future applications in secure communications and data storage.

Atom optics, which aims to control atomic de Broglie waves in an analogous manner to light optics, has developed rapidly in the past 15 years, and Australian researchers have played a prominent role. ACQAO aims to apply quantum optics concepts to atom optics in order to study the fundamental properties of Bose-Einstein condensates (BECs), with potential applications such as gravity gradiometry based on the quantum control of coherent matter waves.

ACQAO is headquartered at the ANU in Canberra, and has major partners at UQ and SUT. The Centre houses the world's only quantum laser pointer as well as Australia's only atom laser experiment located at ANU, the latter based on a rubidium BEC. (There is another rubidium BEC outside the Centre in the UQ Physics Department.) Three more BEC experiments are under development in the Centre, one at ANU (in metastable helium), and two at SUT (rubidium



The atom laser output beam from the ACQAO rubidium BEC: (a) in pulsed mode, (b) in overlapping pulsed mode, and (c) in continuous mode.

Quantum laser pointer laboratory with ACQAO director Hans Bachor and European Partner Investigator Claude Fabre.

on a chip using permanent magnetic microstructures, and a lithium-6 molecular BEC). The experimental activities are integrated with a strong theory core, with the eventual aim of spawning the first-generation quantum technologies.

The Australian Optical Society

The Australian optics community is represented by the AOS[19] and has approximately 300 members across the country. The AOS links its membership through its annual conference and provides connections internationally to optics organizations overseas.

The Society has joint membership agreements with both the OSA and SPIE. To reinforce these linkages, the AOS hosts their respective presidents-elect at the AOS annual conference. Currently there are 137 Australian members of the OSA—roughly 1 percent of total OSA membership—and 61 members of SPIE. AOS members serve on the editorial boards of several OSA journals and many OSA-sponsored conferences.

Australian optics researchers are also key contributors to the growing proportion of authors outside America publishing in OSA journals: Two percent of OSA journal submissions are from Australia, with over two-thirds of all articles coming from outside the United States. And given the rapid growth of Australian research in optics in just over half a century, there is reason to believe that more is yet to come.

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Benjamin J. Eggleton (egg@physics.usyd.edu.au) is an ARC Federation Fellow and Professor of Physics at the University of Sydney, and the Director of CUDOS. For more information on Ken Baldwin, visit www.rsphysse.anu.edu.au/~kgb116/.
OSA Member
To learn more about Ben Eggleton, visit www.physics.usyd.edu.au/cudos/people/eggleton.htm.

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CUDOS

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CUDOS Projects – towards the photonic chip!

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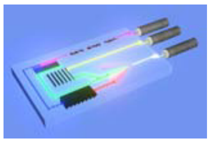
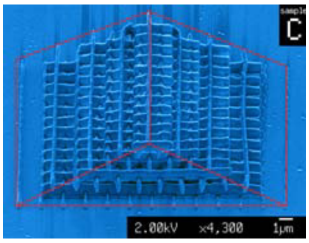
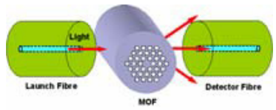
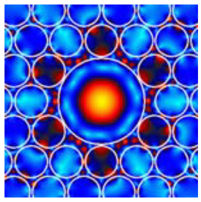


The aim of the **Microphotonics** project is to design, fabricate, characterize and model 3-D polymer-based photonic crystal structures. The demonstration of a photonic crystal superprism is of particular interest because of its startling optical properties.

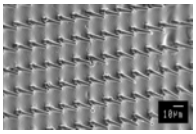


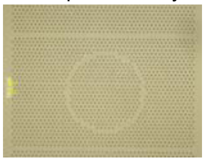
The **Micro-structured Optical Fibre (MOF)** project explores novel MOF designs for use in photonic device applications. MOFS are being explored for device applications and optical interconnects to provide efficient connections from standard single-mode fibers and planar waveguides.



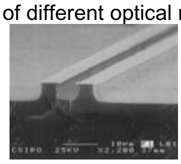


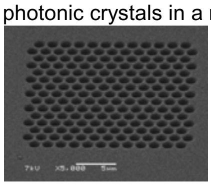
The **Laser Micro-Machining** project develops processes for laser-based micro-structuring of a range of linear, non-linear and high-gain optical materials, to produce photonic structures including waveguides in bulk glasses, 2-D photonic crystals and quasi phase matched crystals.



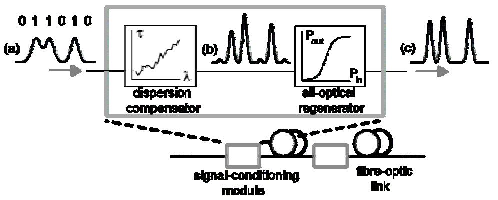


The aim of the **Photonic Integrated Waveguides and Circuits** project is to design, fabricate and characterise planar silicon optical waveguides and 2D photonic crystals in a range of different optical materials.

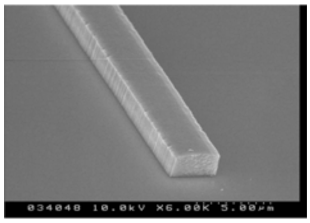




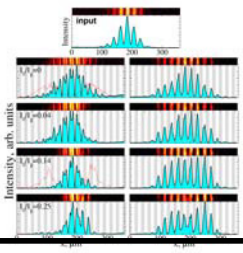
The **Optical devices and Applications** project develops all-optical signal processing functions including regeneration, wavelength conversion and amplification.

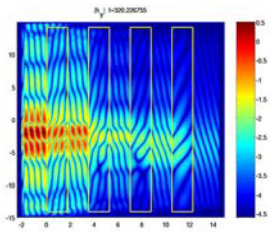


The aim of the **Non Linear Materials** project is to develop high nonlinearity chalcogenide glasses leading to novel nonlinear photonic devices including planar photonic crystals. .

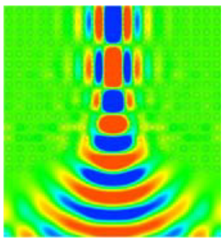


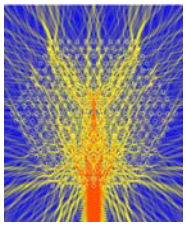
The **Non Linear Photonic Crystals** project studies the generation and propagation of nonlinear localized modes and all-optical switching in periodic photonic structures and waveguide circuits.



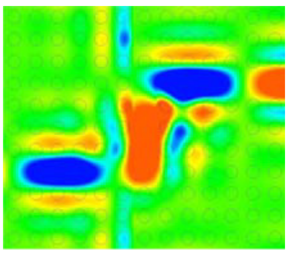


The **Computational Modelling** project provides computational modelling and visualisation techniques through generic modelling tools, new methods for modelling photonic structures and devices, and expertise in visualisation.

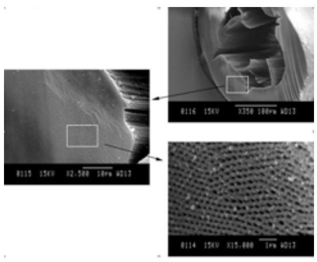




The **Photonic Circuits** project aims to find the best way to achieve tight guidance of light in optical circuits and to optimize photonic circuit features for Fresnel losses, radiation losses and impedance mismatches.



The aim of the **Radiation Dynamics** project is to explore radiation dynamics in microstructured photonic crystal materials. We aim to identify bandgap structures and use quantitative structural information to predict their optical properties.



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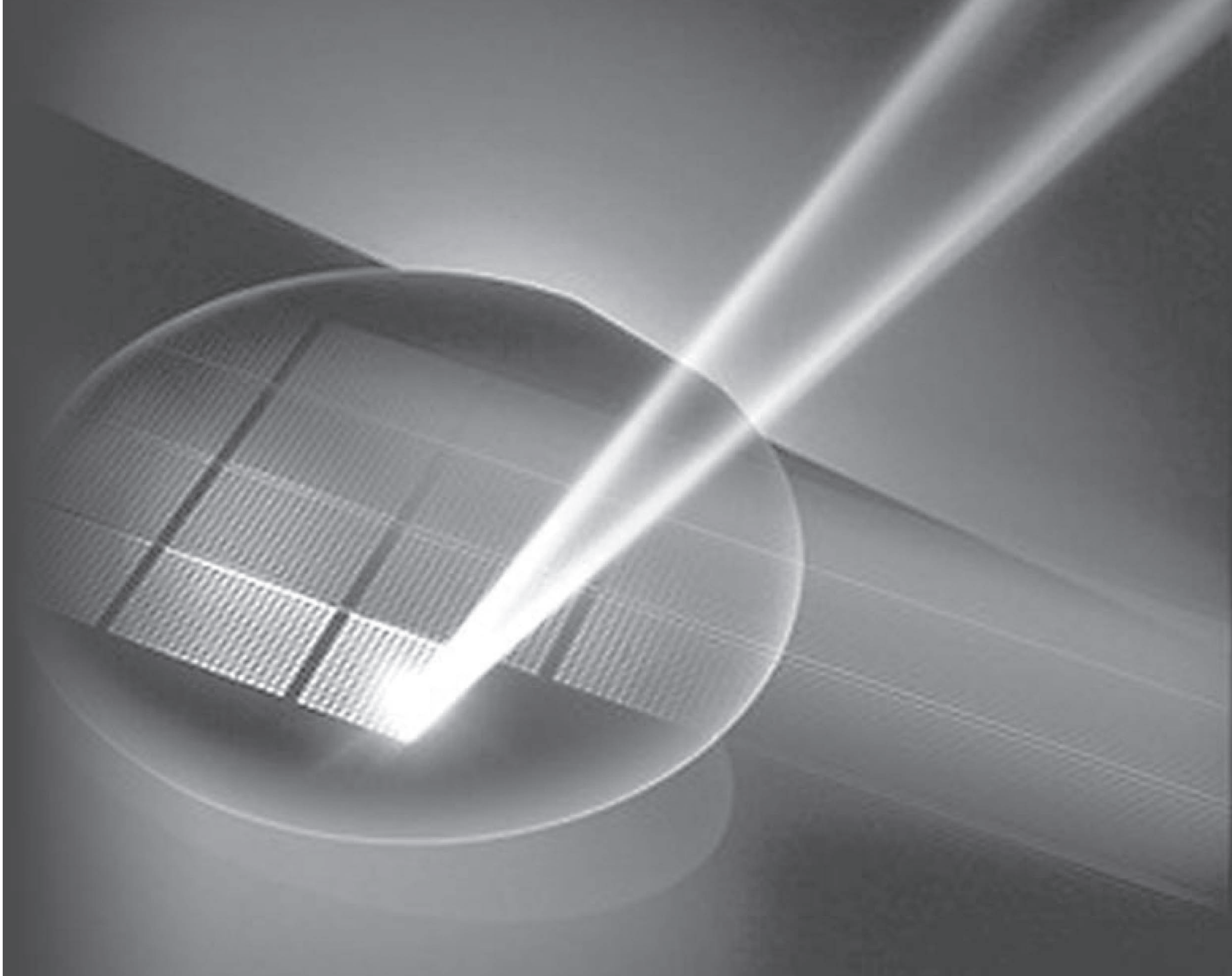

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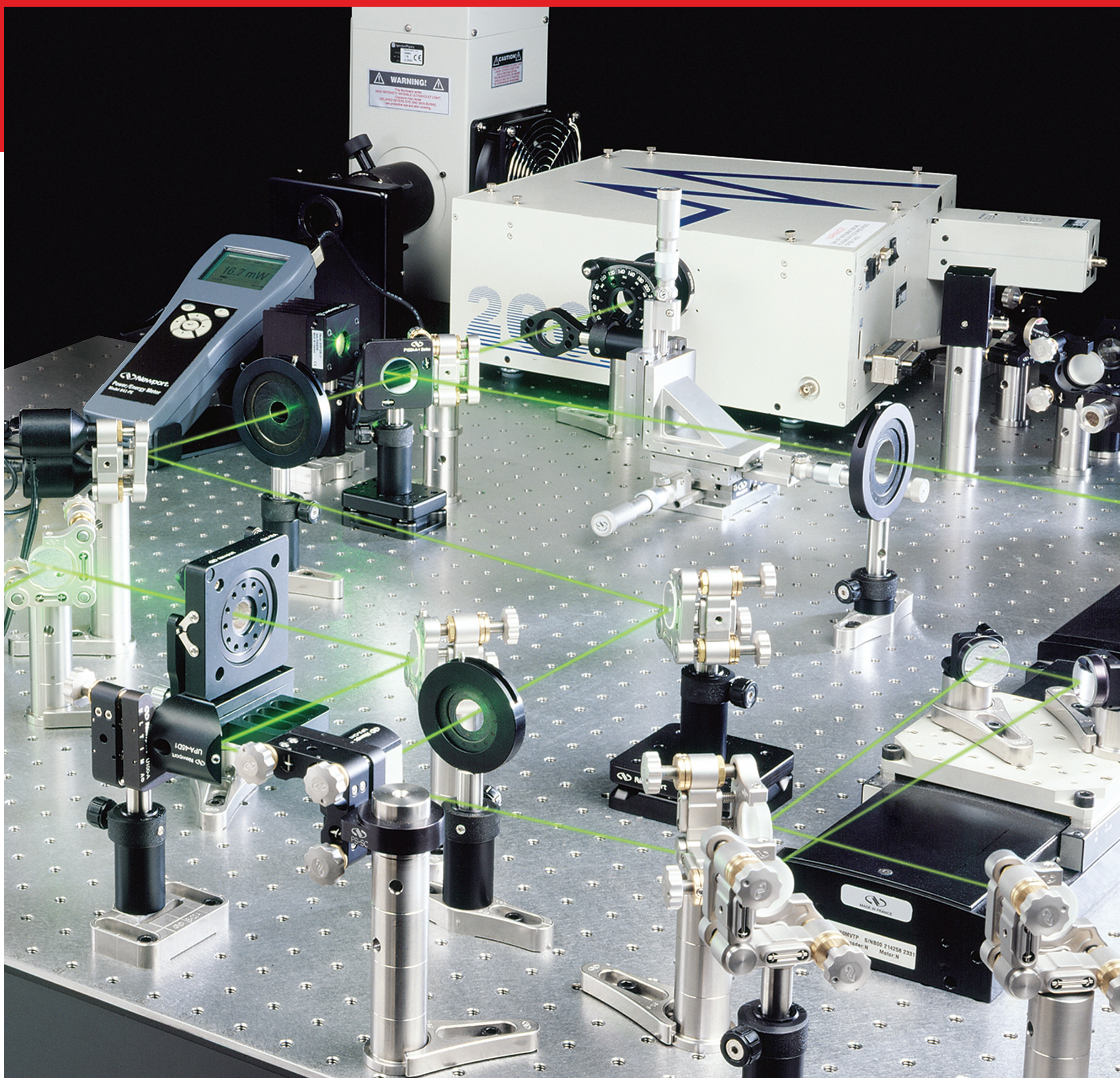

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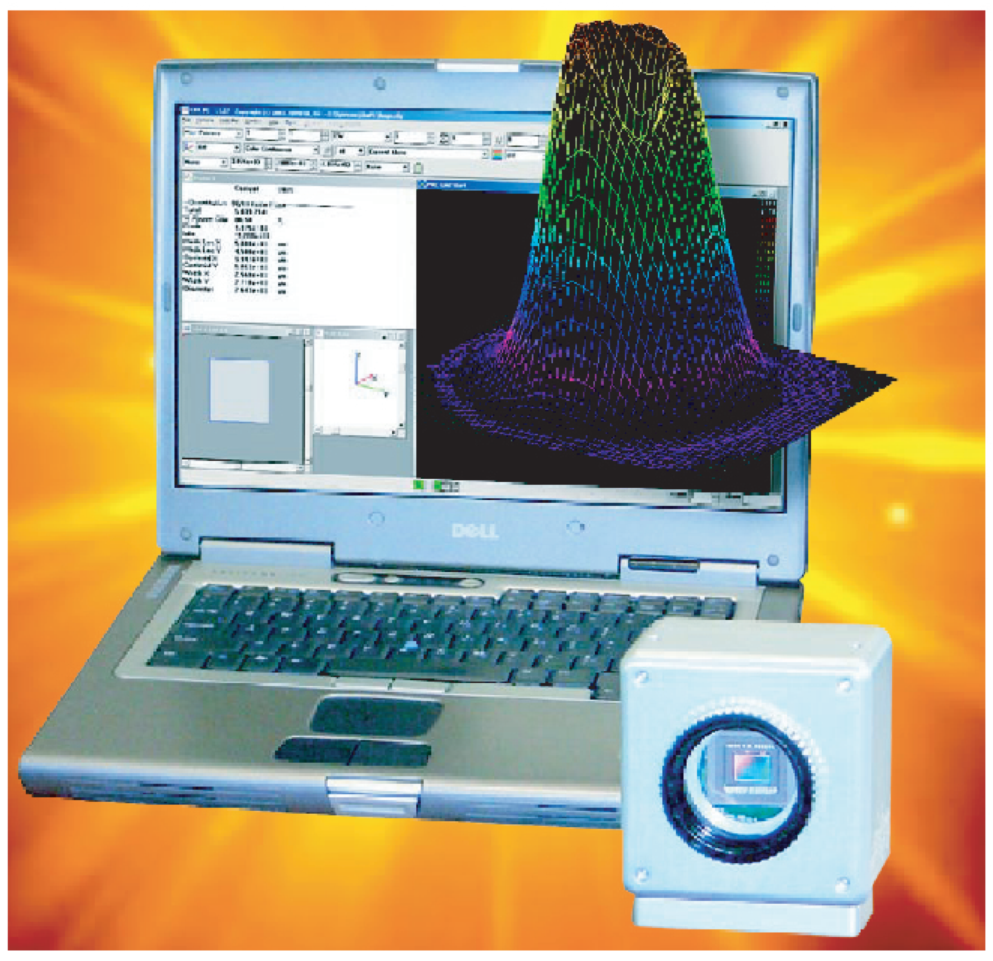

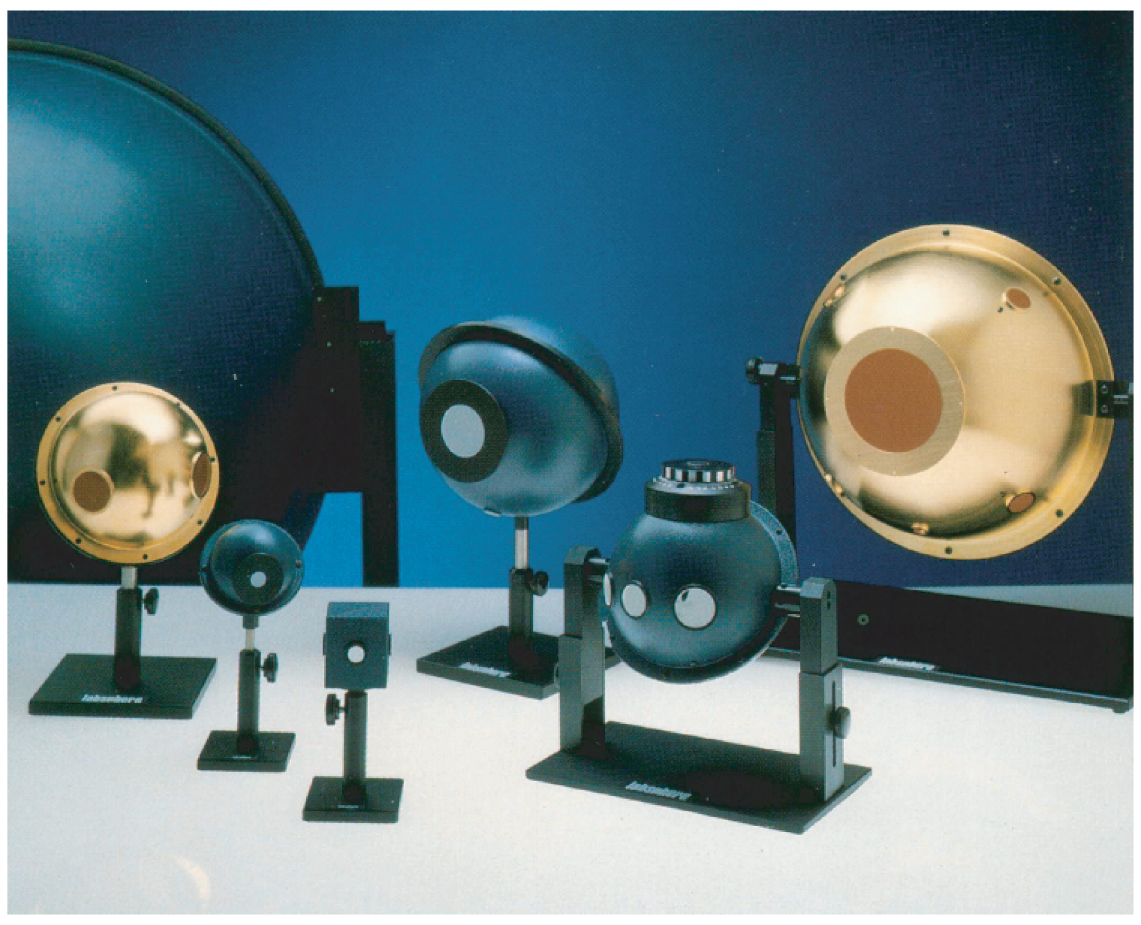

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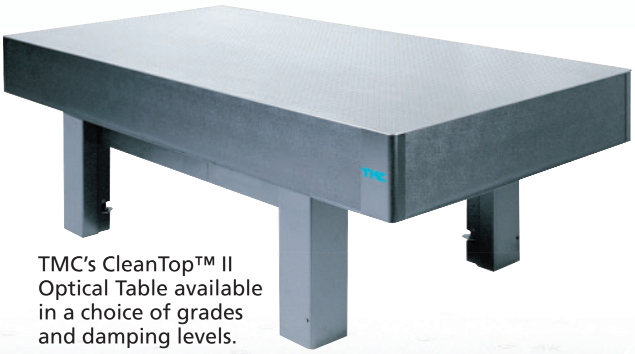

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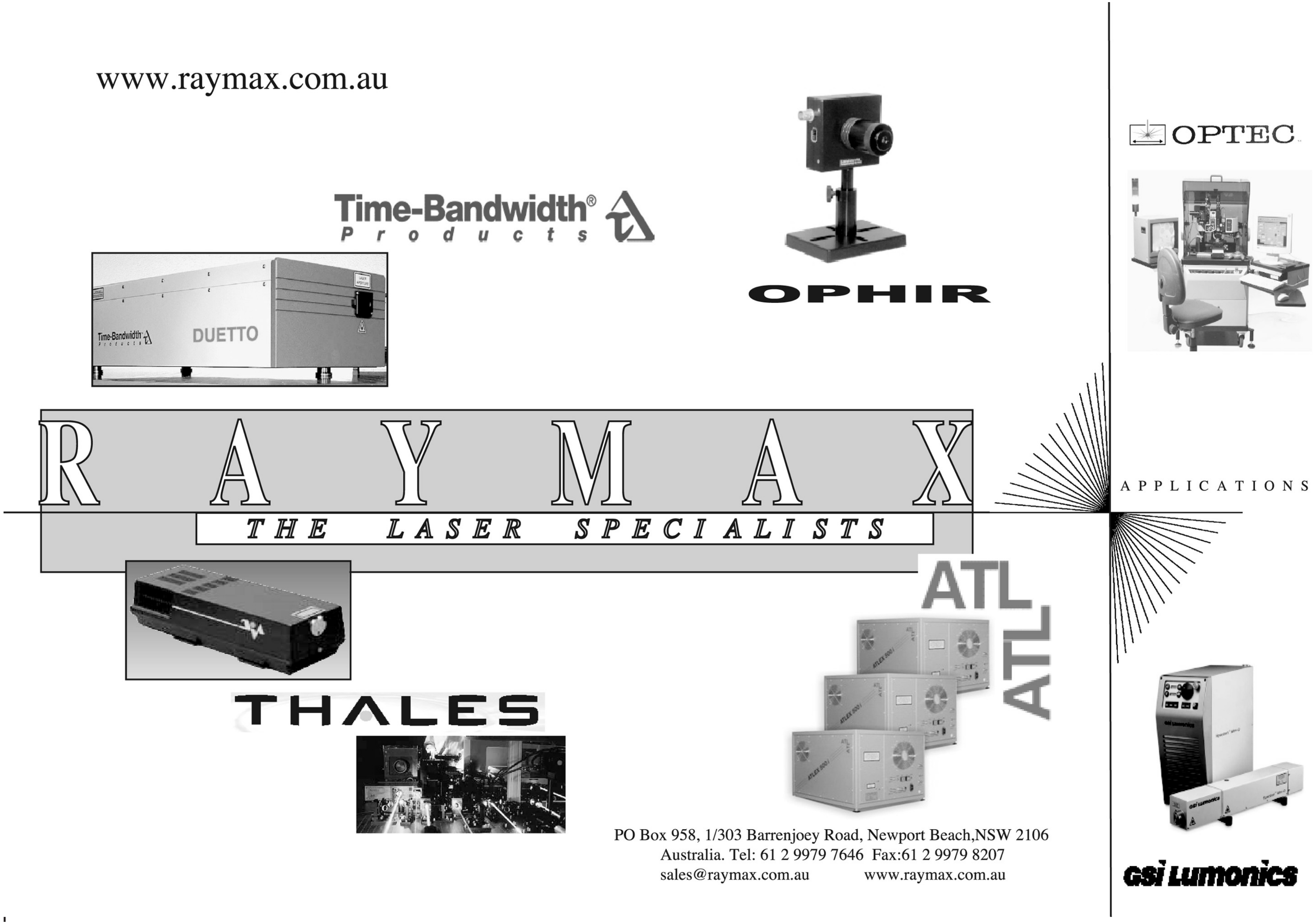

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Quantum science will play a major role in future technology and eventually our daily lives.

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Technically we are now able to use the process of entanglement that was just a concept in the 1930s, and employ it in practical applications, such as communication systems.

We now have the technology for cooling atoms to unimaginably low temperatures and for creating Bose-Einstein condensates. Combining these, we are at the threshold of turning fundamental science into practical applications over the next two decades.

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The Centre of Excellence is part of the vision of the Australian Research Council to promote excellence in the most successful fields of research and to give them the opportunity to become players in the international arena.

The funding and support provided by the Australian Research Council, the three Universities ANU, UQ and SUT and the Queensland and Australian Capital Territory governments will allow us to tackle ambitious Outreach projects, to have an intensive exchange of people, to provide opportunities for young scientists and to build the required research facilities.

Prospects for a Squeezed Atom Laser

Researchers at the ANU Faculty node of the ARC Centre of Excellence for Quantum-Atom Optics have recently showed that generating a squeezed atom laser may be as easy as producing squeezed light.

Certain precision measurements are improved by using slow-moving massive particles. In a Sagnac interferometer, for example, the inherent sensitivity of a matter-wave gyroscope exceeds that of a photon gyroscope with the same particle flux and area by 11 orders of magnitude. Although current atom laser experiments operate in a regime limited by technical noise, the fundamental limit of these measurements will be caused by shot noise. Sensitivity is increased in optical interferometers by squeezing the quantum state of the optical field, where the quantum fluctuations in one quadrature are reduced compared to a coherent state. Sensitivity of an atomic interferometer could be increased by using an atom laser with a squeezed output.

Simon Haine and Joseph Hope in the atom laser theory group in ACQAO have investigated the properties of an atom laser produced by Raman outcoupling from a Bose-Einstein condensate with squeezed light. By modelling the full multimode dynamics of the optical field and the atom laser beam, they showed that under appropriate conditions it is possible to transfer almost the complete quantum statistics of an arbitrary optical state from one of the optical beams to the atom laser beam. They also showed that two-mode optical squeezing, as produced from a non-degenerate OPO, can produce twin entangled atom laser beams propagating in different directions. This may prove to be an easy way to generate entangled atoms to test the behaviour of spatially separated, entangled massive particles.

Further details can be found at http://www.anu.edu.au/Physics/ANUBEC/publications.html

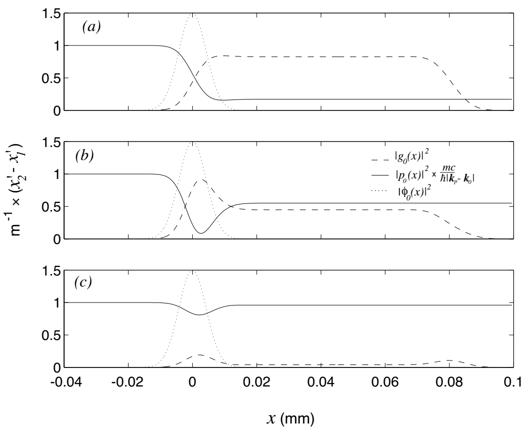

Figure 1: Density of optical probe beam (solid line) and the atom laser beam (dashed line) for different values of the outcoupling strength and the two-photon detuning.

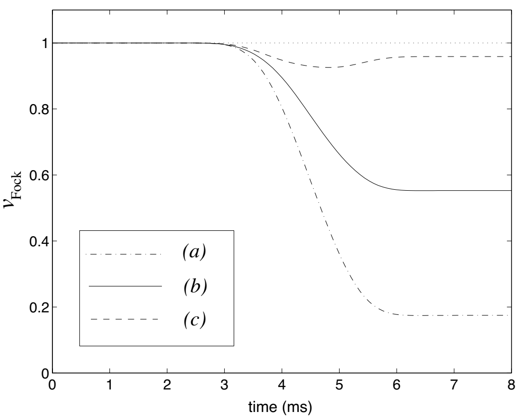

Figure 2: Variance in the flux of the atom laser beam for different values of the outcoupling strength and two-photon detunings. $v_{Fock} = 1$ is the classical shot noise limit.

References

[1] S. A. Haine and J. J. Hope, *'Outcoupling from a Bose-Einstein condensate with squeezed light to produce entangled atom laser beams'*, to appear in PRA.

[2] S. A. Haine and J. J. Hope, *'A multi-mode model of a non-classical atom laser produced by outcoupling from a Bose-Einstein condesate with squeezed light'*, to appear in Laser Physics Letters.

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Photonic Crystal Fibre Tapers: A Promising New Variety of Optical Waveguides

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Abstract

Following a brief review of the design and properties of photonic crystal fibres, we discuss our recent experimental and theoretical studies of tapered forms of these fibres. We observe interesting transmission spectra and explain their form through an analysis of the modal cutoffs of fundamental and higher order modes.

1. Fibres, tapers and photonic crystals

Optical fibres have transformed the way researchers work, not only in optics but rather in *all* areas of research, simply because the Internet would not exist without optical telecommunication technology. Optical fibres are so far the only information carrier able to deliver terabytes of data within seconds across the planet – and there are no signs that optical fibres will be superseded in this role anytime soon. Of course, optical scientists and engineers know that optical fibres are capable of much more than mere data transport. Over the decades since the mid-1970's, fibres have penetrated all kinds of research labs. However, although research into optical fibres has never really slowed in the past thirty years, developments since the late 1990s have attracted a new level of interest from an even broader community than previously.

Photonic Crystal Fibres

The key to this resurgence was the invention of photonic crystal fibres (PCF), an entirely new class of optical fibres based on guidance mechanisms that either extend total internal reflection or bypass it altogether. As the name makes clear, PCFs arose as an off-shoot of the field of photonic crystals (PC). Photonic crystals are a generalization of the well-known Bragg multilayer mirror to higher dimensions – they are periodic structures in two or three dimensions of dielectric or metallic materials. In suitably designed photonic crystals, light of certain wavevectors suffers Bragg reflection, cannot propagate in the PC, and is entirely reflected. The initial idea for PCFs was to use photonic crystals to confine light in the transverse direction only. Light would be free to propagate in the unconstrained direction down the fibre. In this "classic" PCF, a two dimensional photonic crystal, typically a lattice of air holes in a silica background, surrounds a central "core". Light attempting to drift from the core is reflected by the PC back into the core and propagates as a mode of the entire structure. Since reflection by the PC can be obtained regardless of the refractive index of the core material, PCFs can have *hollow* cores (Fig. 1) – a feature impossible in conventional fibres in which the core must have the highest index. The fact that light in a hollow core PCF is guided in air (or vacuum) rather than in a solid dielectric reduces the degree of interaction between light and matter dramatically, leading to fibres with non-linearity and material absorption lowered by orders of magnitude. Such fibres can for example be used to guide light with power densities beyond the damage threshold of conventional fibres [5,6], to guide particles or atoms using optical forces within the fibre core [7], or to compress high power laser pulses [6,8]. On the other hand, the hollow core can be filled with gases or liquids, enabling strong interactions of light with these materials over relatively long distances. This has led to totally novel ways of obtaining high order harmonic generation and ultra-sensitive gas spectrometry [9,10].

In fact, in order to simplify their fabrication, the first PCFs had solid rather than a hollow core [11]. Although solid core PCFs (Fig. 1) don't have the advantages of hollow core guidance, early experiments and theoretical analysis showed that they have their own set of unusual properties. The most striking is that they are single-moded over an infinite wavelength range (so called endlessly single-mode fibres) [12]. A number of other properties first observed in solid core PCFs, including zero-dispersion wavelengths in the visible and very small mode areas [13,14], have subsequently turned out to be due solely to the strong index contrast within PCFs, and are not associated with the periodicity. Similar properties can be obtained in sub-micron silica rods surrounded by air, inaccurately dubbed photonic *nanowires* [15]. The combination of strong confinement and zero dispersion wavelengths around 800nm in both PCFs and nanowires has led to practical and cheap new sources for supercontinuum generation [16,17]. Supercontinuum generation is the broadening of a laser pulse into a pulse or a series of pulses with extremely broad spectral coverage, in some cases covering more than an octave of optical frequencies from the violet to the infrared. The resulting light is extremely bright, can be single-moded over the entire wavelength range (when endlessly single-mode PCFs are used) and has a reasonably flat spectral density. It has been referred to as a *white laser source*, and applications range from high resolution optical coherence tomography [18] to the creation of simple frequency chains able to measure optical *frequencies* (rather than wavelengths) directly [19]. The latter will lead to all-optical clocks that will likely displace atomic

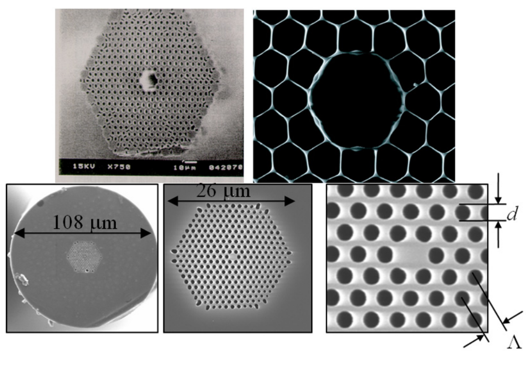

Figure 1. A range of PCFs. Top left: micrograph of a hollow-core PCF from the University of Bath, top right: micrograph of a PCF by Corning; bottom: solid core PCF and close ups. Λ denotes the pitch or centre to centre distance between holes, while *d* denotes the diameter of the holes.

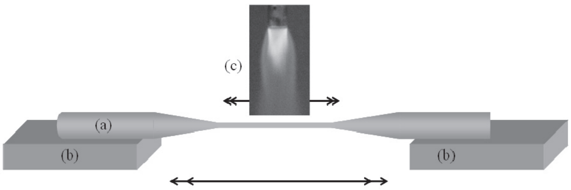

Fig. 2: Fibre taper rig. A fibre (a) is clutched on two translation stages (b) applying tension to the fibre. A flame (c) brushes the fibre while it is being elongated by the translation stages.

clocks as the fundamental time standard at some point. Their increased accuracy, cost-effectiveness and usability will open new avenues for fundamental physics such as tests for changes of in the values physical constants over time.

Fibre Tapers and Nanowires

As already mentioned, some of the most interesting properties of solid core PCFs can be obtained in plain silica rods with micrometric diameters. Various techniques have been demonstrated to generate such narrow fibres, with diameters down to only 50 nm [15], the simplest one being the tapering of conventional optical fibres [20,21]. Fig. 2 shows how a typical fibre tapering rig works: a fibre is clutched between two translation stages which pull the fibre from both ends so as to elongate it while a flame brushes the fibre back and forth. The flame softens the fibre to the point where the tension applied by the translation stages is enough to elongate the fibre, without melting it entirely.

Tapered optical fibres have been investigated since the 1970s, traditionally for use in all-fibre directional couplers, acousto-optic in-fibre couplers, and other passive devices [22-24]. While fabricating an optical fibre from scratch is a complex process requiring expensive equipment, a taper rig is relatively easy to assemble and allows tuning and post-processing of readily available fibres including standard off-the-shelf products. It is only recently however that researchers have demonstrated just *how far* fibres can be tapered, and how useful tapers with sub-wavelength diameters might be. The benefits of these nanowires are threefold [25]. First, since the refractive index contrast at the air-silica interface is much larger than found in conventional single mode step index fibres (SIF), they exhibit very strong waveguide dispersion, which can compensate material dispersion so that the local value of dispersion parameters can be adjusted within a very wide range. Second, again as a result of the large refractive index contrast, they allow strong confinement of light, with effective areas of the order of 1or 2 μm^2, and non-linear coefficients increased by up to two orders of magnitude compared to standard SIFs. The strong confinement also leads to a very low sensitivity to bends, with reported nearly-lossless bends at bend radii of only a few micrometers. And third, fibre tapers with small diameters are small. Since the field is well confined, nanowires can be packed closely together. They can be bent on micrometric distances. It has been suggested they could be used as the building block of photonic chips – the holy grail of photonics – although a process to fix them *en masse* as circuits on a substrate has yet to be found.

Microstructured fibre tapers and nanowires

It was demonstrated recently that PCFs could also be tapered, with their transverse microstructure being conserved (Fig. 3) [26-28]. In the case of hollow core PCFs, tapering allows the bandgaps of their cladding to be shifted to any desired wavelength, just by downscaling the photonic crystal within the PCF. In the case of solid core PCFs, tapering allows the tailoring of their dispersion and confinement properties. It has been suggested that by micro-managing a PCF's dispersion along their axis through tapering, solitons could be compressed and supercontinuum generation could be optimized [29]. In non-microstructured nanowires of sub-wavelength diameters a large part of the guided energy lies outside the fibre in the form of evanescent fields, which makes nanowires sensitive to surface contamination. By using microstructured nanowires, the evanescent part of the field can lie within the holes of the microstructure, without reaching the surroundings of the nanowires. The fields are then protected from surface contamination, and microstructured nanowires can be directly fixed to high-index substrates without the field leaking into the substrate [27]. Finally, one can locally collapse the holes within the nanowires by applying heat. On the short stretch of nanowires where the holes are collapsed, the evanescent fields reach far outside the fibre and can be used to probe optical properties locally [30]. Given their dimensions, such a taper could for example be used for in-vivo spectral analysis or, in combination with microfluidics, be integrated in lab-on-a-chip devices.

In the remainder of this article, we will discuss in more detail several aspects of microstructured tapers that have been studied at the CUDOS node at the University of Sydney. We concentrate on a physical phenomenon underpinning most of the above mentioned properties and applications, namely mode transitions in these tapers. Indeed, depending on the wavelength and size of the taper, a mode can be in one of several states: confined within the core, confined in other parts of the fibre, or not confined at all. The transition between these states can be abrupt in the case of higher order modes (in which case they are equivalent to the well known phenomenon of modal cutoff), or gradual, as is the case for the fundamental mode. It should be emphasized that the physics behind mode transitions is not, in fact, specific to microstructured tapers, but can be found in conventional fibre tapers. However, because of the higher refractive index contrast and the complexity of the structures within PCFs, transitions tend to be more dramatic and complex, and lead to phenomena rarely seen in conventional fibre taper geometries. Understanding these transitions is a prerequisite for the design of usable PCF taper devices, since they dictate fundamental limits to the range of wavelengths for which a taper can be used but also give indications on how to obtain desired properties.

2. Fundamental mode "cutoff" in PCF tapers

2.1 Observation – the index matched case

Figure 4 shows the transmission spectra of tapers made from a PCF similar to that at the bottom of Fig. 1, with various waist diameters [31]. Light from a broad band source is injected in the fundamental core mode of the fibre at one end of the taper and is measured by an optical spectrum analyser at the other end. The tapers are immersed in index-matching

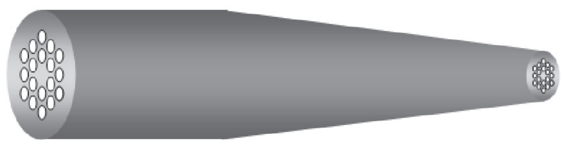

Figure 3. Schematic of a tapered MOF in which the hole structure is preserved.

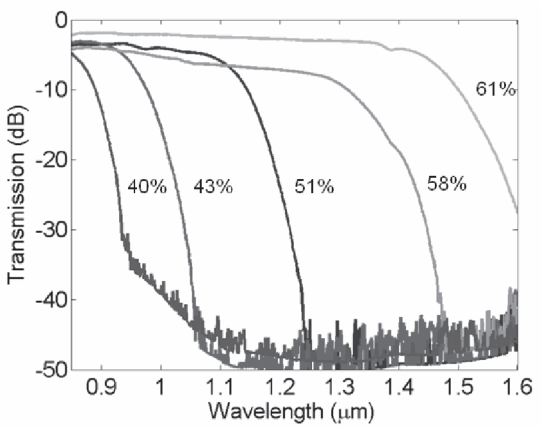

Figure. 4. Longitudinal transmission spectra of various tapers. Percentage values indicate the ratio of the outer diameter at waist normalized to the initial outer diameter.

oil, to characterise the transmission spectra of the light that is confined purely by the microstructure. A sharp long-wavelength loss edge is observed for all tapers, and the cutoff wavelength decreases clearly with decreasing outer diameter at the waist of the taper. Tapers have been designed to be adiabatic following a criterion valid for PCFs with infinite number of rings of holes surrounding the core [20].

2.2 Interpretation

Since the PCF is immersed in index matching fluid, the microstructured part of the fibre (or cladding) is solely responsible for confinement of light within the core. The PCFs have a finite number of rings of holes, and the potential barrier isolating the core from the outside is therefore of finite width. There are no properly bound modes in such an open boundary problem; light propagation in such a case can be described in terms of leaky modes [32].

When the wavelength is short compared to the local centre-to-centre distance between holes (or pitch, Fig. 1), the fundamental mode is well confined in the PCF core. The evanescent tail of the mode in the cladding decreases rapidly away from the core, and virtually no field can leak beyond the cladding. When the wavelength becomes comparable to the pitch, the mode spreads into the microstructured region (or cladding). A non-negligible fraction of the evanescent field reaches beyond the cladding and radiates away. Thus a mode with wavelength shorter than the smallest pitch encountered along the taper remains confined along the entire taper, with low propagation loss, and since the taper is adiabatic, near-unity transmission is observed in that regime. However, at wavelengths comparable to the pitch at the waist of the taper, the propagation loss becomes significant near the waist and the transmission drops.

2.3 The non-index matched case

When a PCF is surrounded by air rather than being index matched, the fundamental mode leaking beyond the cladding at long wavelengths remains confined by the external silica/air boundary. The mode is genuinely bound, rather than leaky, and no propagation losses can be expected from the mechanism explained above. However, experiments show that the transmission still drops dramatically at the same wavelength as in the index matched case [31]. To be more precise, the transmission drops abruptly, but not indefinitely with increasing wavelength. It stabilizes at a low level (5 to 30 dB depending on the PCF one starts with), sometimes with visible oscillations with varying wavelength.

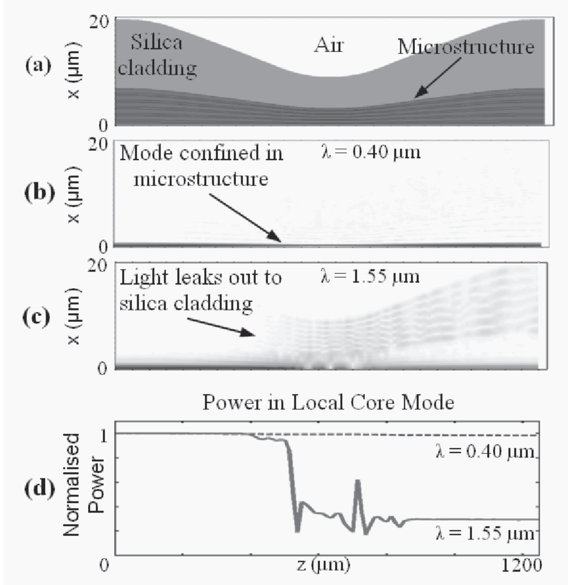

Fig. 5. (a) Cross-section of the simulated PCF taper: the field is launched from the left at z = 0; Field evolution of the core mode at (b) λ = 0.40 μm and (c) λ = 1.55 μm; (d) Fraction of power of the propagating field that occupies the fundamental mode of the *local* structure.

The level at which the transmission stabilizes as well as the amplitude of the oscillations are in fact largely determined by the size of the region between the holes and the outer PCF boundary. This indicates that the transmission drop is due to coupling to cladding modes that propagate in the outer part of the fibre. Indeed, the larger that region is, the more modes it can carry. When the fundamental mode starts leaking beyond the cladding, it can easily couple to those modes. This leads to mode beating (resulting in the observed oscillations), and because the numerous modes to which the fundamental mode couples all have different phase velocities, the field at the end of the taper cannot be reconstructed into a fundamental mode, resulting in the low transmission. Fig. 5 shows results from a beam propagation simulation illustrating this behaviour. The simulated structure is similar to that in Fig 1 (bottom), but with only five rings of air-holes and a reduced thickness of the silica cladding. The minimum and maximum pitches of the taper are 0.58 μm and 1.28 μm, respectively. Fig. 5 shows the field evolution as the mode propagates through the taper, at wavelengths below and above the cutoff corresponding to the minimum pitch. At the shorter wavelength (Fig. 5(b)), the light remains in the microstructure, with near-unity transmission through the taper. At the longer wavelength (Fig. 5(c)), some light leaks out to the cladding, where the oscillation in intensity along the taper-waist correlates with the propagation of higher-order modes.

Figure 5(d) shows the fraction of optical power in the propagating field that is in the fundamental core mode of the local structure. At the shorter wavelength below the cutoff (λ = 0.40 μm), this quantity remains near-unity through the entire taper, indicating that the core mode adiabatically contracts and expands as it propagates, without exciting higher order modes. In contrast, at the longer wavelength (λ = 1.55 μm), the power in the local core mode drops dramatically near the taper waist, exactly where the field distribution has expanded to fill the entire fibre cross-section in Fig. 5(c). Only 29% of the power remains in the fundamental core mode as the fibre up-tapers; the rest of the energy is in the cladding modes which are eventually lost.

In fact, if the taper was truly adiabatic, no such mode coupling would occur, and the fundamental mode would adiabatically return to its confined state at the end of the taper, regardless of the wavelength. The adiabaticity criterion we used, which is only valid for an infinite number of rings of holes around the core, has to be reconsidered to take into account the possible coupling with modes between the holes and the fibre boundary. It appears that the revised adiabaticity criterion requires taper lengths diverging rapidly with increasing size of the silica region beyond the holes, and that satisfying the revised criterion requires tapers of impractically long lengths.

2.4 Discussion

The cutoff of the fundamental mode in PCF taper as described above imposes restrictions on the wavelength range given PCF tapers can be used for, and has to be kept in mind when designing PCF tapers. Rather than a limitation, the optimist will see in the fundamental mode cutoff an opportunity to design in-fibre short-pass filters. Finally, it is worth noting that the fundamental mode cutoff, although not familiar in the world of standard single mode fibres, is not specific to PCFs. The same phenomenon occurs for essentially the same reasons in depressed cladding fibres when the core and the outer cladding have the same refractive index [33], and other similar phenomena exist for all sorts of tapers. However, because of their particular geometry, it is only for PCFs that the fundamental core mode cutoff results in such a sharp drop in transmission.

3. Mode transitions in “grapefruit” tapers

3.1 Three states of the light

The cutoff of the fundamental core mode in solid core PCFs is linked to the size of the region between the holes and the outer fibre boundary. By reducing the size of that region dramatically, the cutoff can be avoided, and instead of a mode transitioning between a confined and a highly leaky state, we can obtain a mode able to transition adiabatically from being strongly confined in the core to being confined by the outer fibre boundary. Further, we have seen that it is the high index contrast between holes and the background, rather than the arrangement of the holes, which provides strong confinement in the core. Fig. 6 shows the cross-section of a “grapefruit” fibre which satisfies both conditions of high index contrast and a small distance between the holes and the outer boundary. Depending on the ratio of the outer diameter OD to wavelength λ of light guided in such a fibre, guidance can occur in three different regimes (Fig. 7, left) [27]. At short wavelengths (large *OD/λ*), light is well confined in the central silica region (the core). At wavelengths comparable to the core size, the evanescent tails of the mode within the holes start to carry a significant part of the energy. However, the mode remains well confined by the outer boundary, and the evanescent part of the fields within the holes are unaffected by the fibre’s surroundings (*embedded regime*). Finally when the wavelength becomes larger than the OD, the mode is only weakly confined by the outer boundary of the fibre, and evanescent tails reach outside the fibre (*evanescent regime*). Figure 7 compares the modal fields in these three regimes mode profile of the grapefruit fibre in this regime is very similar to that of the 725†nm silica nanowire as shown in

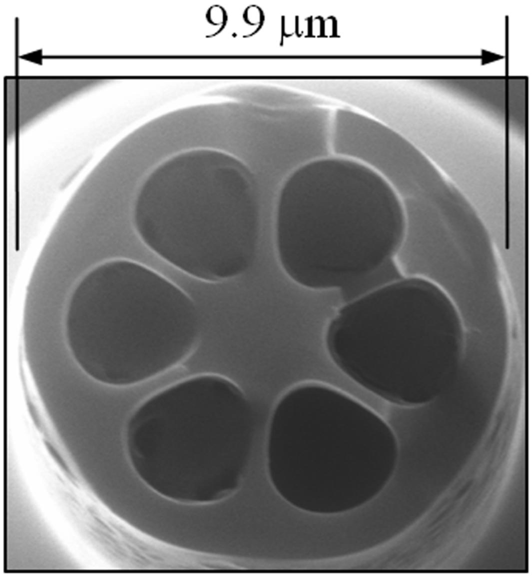

Fig. 6. Micrograph of the cross-section of a grapefruit fibre tapered down to an outer diameter of 9.9µm.

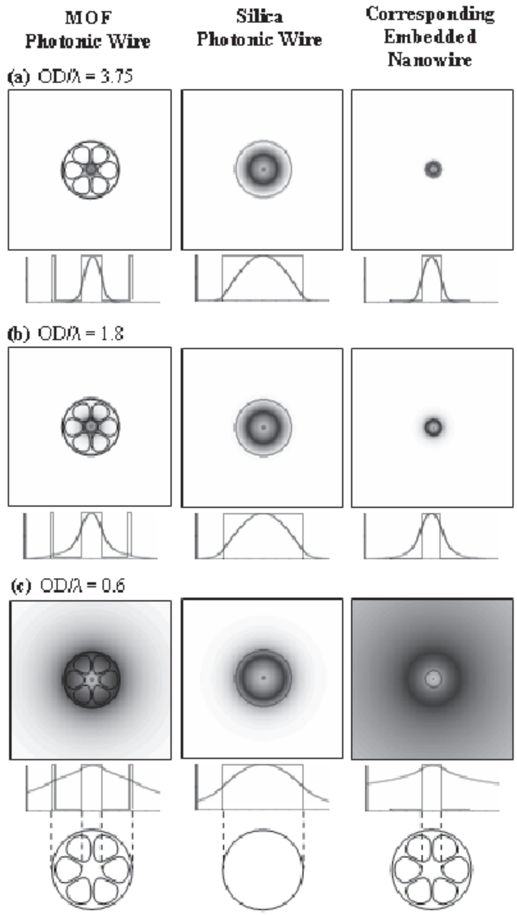

Fig. 7. Calculated mode intensity profile for (left) the tapered grapefruit fibre; (centre) pure silica photonic wires; and (right) silica nanowires corresponding to the inner waveguiding region of the grapefruit fibre. The mode profiles are plotted for outer diameter to wavelength ratios (OD/λ) of (a) OD/λ = 3.75 where the mode is in the *embedded* regime and is isolated from the environment; (b) OD/λ = 1.8 – a transition regime; and (c) OD/λ = 0.6, where the mode is in the *evanescent* regime. Below each contour plot are the superimposed intensity and refractive index profiles along a horizontal section through the centre of the corresponding photonic wires.

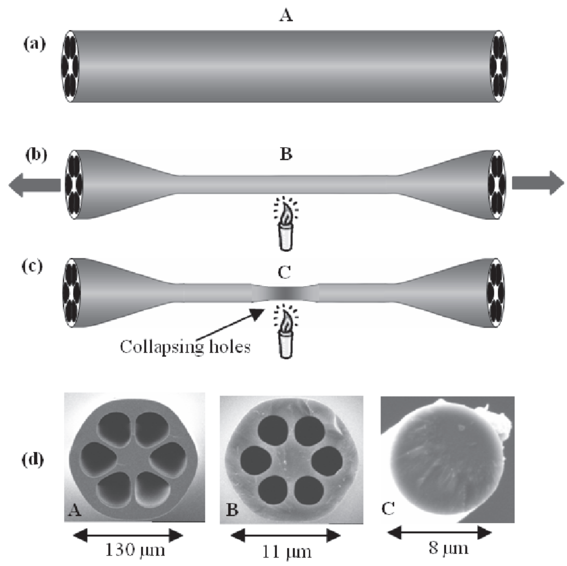

Fig. 8. Schematic of: (a) untapered grapefruit fibre (b) grapefruit photonic wire tapered by stretching under a brushing flame, while maintaining the air-holes; (c) the local heat-treatment of the tapered grapefruit fibre, where it is held stationary under a flame, causing the air-holes to collapse; (d) cross-sectional micrographs of the grapefruit fibres in (a) – (c).

with those of a single silica rod of the same diameter as the OD of the grapefruit fibre (Fig. 7, centre) and of same diameter as the grapefruit fibre core, calculated with a beam propagation method.

Fig. 7 (a) (left) shows the mode profile of the grapefruit fibre in the *embedded* regime, at $OD/\lambda = 3.75$. At a wavelength of λ=633 nm this example corresponds to $OD = 2.3$ µm, and a core of approximately 725 nm in diameter. Here, the mode is tightly confined in the core of the fibre and isolated from the external environment, unlike the plain silica photonic wire with the same OD, where the mode spans the entire cross-section of the fibre as shown in Fig. 7(a) (centre). In fact, the mode profile of the grapefruit fibre in this regime is very similar to that of the 725 nm silica nanowire as shown in Fig. 7(a) (right). However, while the evanescent tail of the mode in the silica nanowire is in the surrounding free space, the evanescent field of the mode in the grapefruit fibre is mostly in its holes, isolating the mode from the external environment. By contrast, when OD/λ is further reduced, either by further tapering of the nanowire or by operating at longer wavelengths, the mode begins to leak out of the air-holes, as illustrated in Fig. 7(b). This transition occurs at a value of approximately $OD/\lambda = 1.6$. Finally, at even smaller values of OD/λ when the grapefruit fibre is in the *evanescent* regime, the mode fills the entire fibre and most of the mode intensity is guided outside the fibre: for $OD/\lambda = 0.6$, 70% of the intensity is outside the fibre. Interestingly, the intensity guided outside the grapefruit fibre in this regime is greater than the corresponding field in a plain silica wire with the same OD, and is therefore more sensitive to the external environment.

Note that in a standard SMF fibre taper, the mode also transitions from being confined in the core to being confined by the outer cladding boundary, to being evanescent. However, because of the small index contrast between core and cladding, and the large size of the cladding compared to the core, an adiabatic transition between those regimes requires much longer taper lengths than with the grapefruit taper.

The mode properties of the grapefruit tapers are ideal for sensing applications, and spectroscopic and fluorescent sensing devices have been demonstrated using SMF tapers [34, 35]. The *embedded* regime in the grapefruit fibre extends down to much smaller OD than in the SMF, enabling ultra-compact optical delivery mechanism that can be integrated on to chip-based device platforms. A section of this photonic wire can then be further tapered into the evanescent regime and positioned in a fluid-filled channel or compartment for sensing purposes. In addition, the increased energy in the evanescent field that is guided outside the grapefruit fibre in this *evanescent* regime gives rise to a more sensitive sensor than an SMF with the same OD.

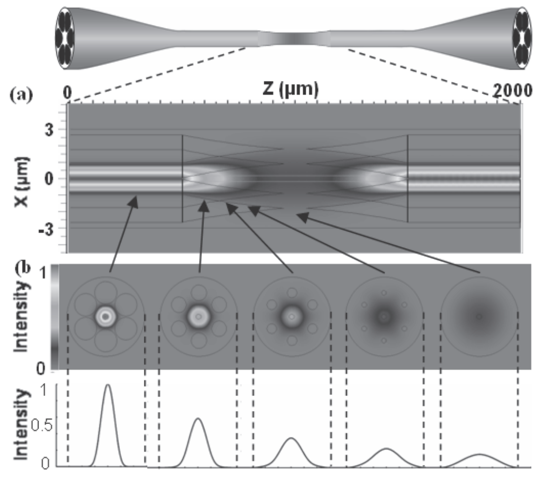

Fig. 9. (a) Simulated evolution of the field intensity as the core mode propagates through a region of the photonic wire where the holes collapse and re-appear. The thin lines represent the outline of the taper and collapsing holes. (b) Cross-sectional field intensity distribution at various positions along the taper, as the mode propagates through the heat-treated region.

3.2 Collapsing the holes

Although tapered MOFs promise to be ideal structures for evanescent-wave sensing, many biological sensing applications operate at visible wavelengths, and therefore require the MOF OD to be less than a few microns. One difficulty in fabricating such small tapers is the collapse of the air-holes. Although possible in principle, tapering the MOFs down to these structural dimensions while preserving the cross-sectional structure is not trivial. As it turns out, however, it is possible to take advantage of the air-hole collapse [30].

A tapered grapefruit fibre can be made to transition between the *embedded* and *evanescent* regimes through controlled collapse of the air-holes over a localized region. Instead of further shrinking the entire fibre, the grapefruit taper is post-processed in the waist region, where the mode is still embedded. The mode is allowed to expand by removing the air-holes that act to confine the mode, essentially transforming the grapefruit fibre into a solid rod of silica. By collapsing the air-holes gradually along a length of the tapered grapefruit fibre, the expanded mode is able to contract back into the core adiabatically with low loss, when the air-holes reappear further along the taper.

Figure 8 illustrates the geometry of the hole-collapsed photonic wire. The grapefruit fibre is adiabatically tapered down to a waist of $OD = 11$ µm and several centimetres in length, initially without collapsing the holes. The waist of the taper is then post-processed by applying the flame without stretching the fibre (Fig. 8(c)). This localized heating allows the surface tension of the silica to collapse the holes over a small length of the taper, determined by the heat distribution. Consequently, this further reduces the waist diameter to 8 μm. SEM images of sections of the taper with and without the air-hole collapse are shown in Fig. 8(d).

Figure 9(a) illustrates the principle of the expanding mode through a simple BPM simulation, using a 6 μm structure with circular air-holes. These simulations show the field intensity evolution of the fundamental mode at 1.55 μm wavelength, propagating through the 2000 μm length waist of a tapered MOF, in which the air-holes collapse and re-appear. As the air-holes collapse, the initially-confined mode expands, eventually spanning the entire cross-section of the fibre and confined by the outer silica-air boundary (Fig. 9(b)). When the holes disappear completely, a small portion of the field extends beyond the fibre boundary and becomes highly sensitive to the surrounding. Similarly to an SMF taper, the evanescent field is weak at this diameter, and the propagation is strongly affected only when the taper is index-matched. It is possible, however, to increase the evanescent field protruding outside the fibre by further tapering the fibre to smaller dimensions. As the holes re-appear, the expanded mode contracts and once again becomes confined in the core by the air-holes, eventually resembling the launched mode. The simulation yields negligible loss from the propagation, indicating a adiabatic collapse and reappearance of the air-holes.

Figure 10 shows the transmission spectra of a tapered grapefruit fibre, before and after heat-treatment, where the loss is below 0.1 dB when the fibre is initially tapered. This loss remains under 1 dB when the air-holes are collapsed through heat-treatment, suggesting the mode re-adjusts itself as the holes re-appear further along the taper. Oscillations start to appear in the spectrum, indicating coupling to, and beating with, higher order modes. Figure 10 also shows the spectra of the taper immersed in index-matching fluid, before and after heat-treatment. Prior to heat-treatment, the spectra of the taper with and without index-matching overlay each other almost perfectly. This indicates strong isolation of the mode from the environment while the air-holes are open. However, when the heat-treated taper is index-matched, the transmitted power is strongly attenuated by over 35 dB, in the 1200 to 1700 nm wavelength range. This is a strong indication that the collapse of the air-holes has allowed the mode to expand to the outer boundary of the fibre, becoming extremely sensitive to external disturbances.

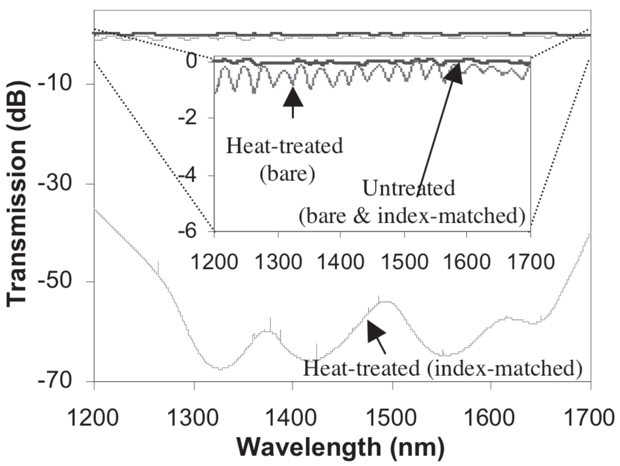

Fig. 10. Transmission spectra of tapered grapefruit fibre referenced to the untapered fibre. Prior to heat-treatment, the bare and index-matched tapers have almost-identical spectra. After heat-treatment, when the holes have collapsed, the transmission in the index-matched case is lower by over 35 dB.

4. Conclusion

PCF have affected the fibre research community on two fronts. While the design and fabrication of PCFs with properties found in no other fibres such as air-core guidance is a profound development, their impact on our understanding of conventional fibres has been just as deep. Numerous effects first observed in PCFs have subsequently been repeated in simpler structures, once researchers knew to look for them. In the present case, the cutoff properties associated with tapering that we have described, are all found to a greater or lesser degree in other fibres, but it is only the flexibility and variability of photonic crystal and micro-structured fibres which allows to understand these effects more deeply and proceed towards the creation of devices that exploit them.

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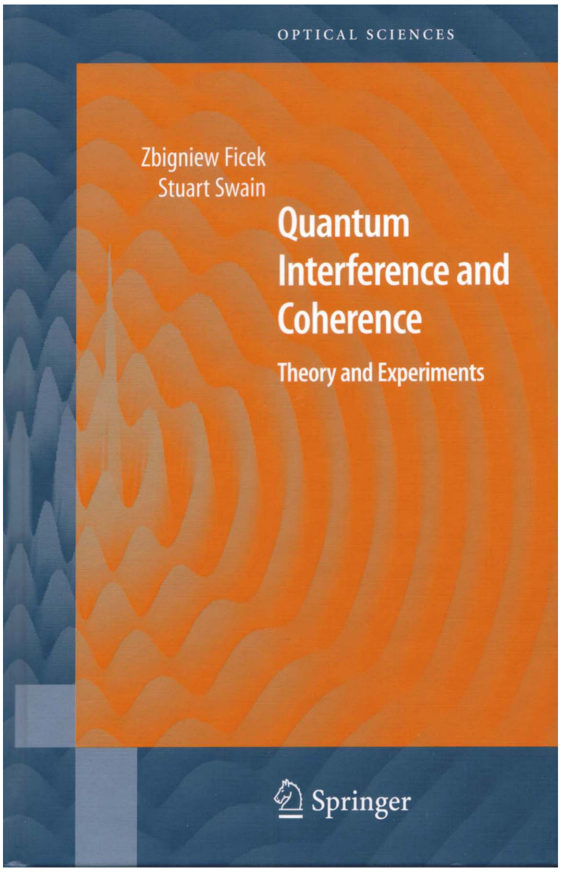
Book Review.



Quantum Interference and Coherence: Theory and Experiments

Zbigniew Ficek and Stuart Swain

Our understanding of the intricacies of quantum mechanics flows, inexorably, from the consideration of optics. The manifestation of wave-particle duality in light, the photo-electric effect, quantum coherence, entanglement and other phenomena speak of the power and insight gained from having accessible and controllable quantum systems. Given that we have been exploring quantum mechanics, and specifically quantum optics for 100 years now, one might have thought there was nothing new to say – nothing could be further from the truth! In fact quantum optics and the exploitation of quantum interference is in high demand these days as researchers strive to translate quantum phenomena from research laboratories into technological applications. Against this backdrop, Ficek and Swain's excellent book is a timely addition to the quantum canon.

This work is more heavily slanted towards theory than experiment, but illustrates the theoretical results nicely with due reference to the important experiments. This is a welcome feature which improves readability of this work over many of its more theoretical companions which are not so well grounded. This book sits (both metaphorically and on my bookshelf) between Bachor and Ralph – *A guide to experiments in quantum optics*, and Mandel and Wolf – *Optical coherence and quantum optics*. More theoretical than the former and with more pictures than the latter, I can see this becoming one of my first ports of call when researching topics.

Although the title is 'Quantum interference', the authors are really dealing with *optical* interference. And optical interference is treated in all its guises: classical and quantum interferometry, light-matter interactions (driven, vacuum induced, and cavity mediated) in two and multi-level atoms, non-classical light and phase-space interference, and atom optics. Starting with a treatment of interferometers and interferometry, the authors contrast classical and quantum effects nicely, repeating calculations in both cases. Such an approach is especially welcome: particularly as the precision of experimental apparatus improves.

But where the book really shines is in its treatment of light-matter interactions. Some two thirds of the book deals with the properties of driven atoms. Using the essential language of density matrices and master equations, the reader learns of the fundamentals of driven systems, cavity effects (full and half cavities), decoherence free subspaces, electro-magnetically induced transparency, slow and fast light, propagation in optically dense media and photonic bandgap structures, amongst others. All these topics are treated with rigour and clarity, and accompanied by figures showing pertinent experimental results.

One notable omission for me, however, was the lack of mention of post-selected effects, such as are harnessed for the realization of quantum gates, for example the KLM (Knill-Laflamme-Milburn) quantum computing scheme. Still, the fine treatment of Hong-Ou-Mandel interferometry will prepare students wishing to progress into Linear Optics Quantum Computing.

I would recommend this book as a useful addition to any optics research library. I would not give this book to undergraduates, however, as I fear it may scare some of them off, but it would be a useful reference when preparing material for a quantum optics course. The stated aim of the Springer Series in Optical Sciences is to generate books "Öof use to all research scientists and engineers who need up-to-date reference books." and this work succeeds admirably in that respect.

Dr Andrew D. Greentree
Centre for Quantum Computer Technology
School of Physics
University of Melbourne, 3010

Report on Science meets Parliament 2005

Summary

Overall, SmP 2005 was successful and has received highly favourable comments from Parliamentarians, participants and sponsors.

As a result, the FASTS Board has determined that SmP should be presented again in 2006. There was a strong view that the move from the 2nd half of the year to March was successful and that will be retained in 2006. The Board also considered the forums to be a useful addition to the structure of SmP and these are to be enhanced next year. In addition, the briefing day will have a stronger emphasis on professional development and understanding of the policy process.

Key features of SmP 2005 were;

- Much greater emphasis on proper matching of Parliamentarians' choices and participants' expertise;
- Greater emphasis on the 'science' as distinct from generalized lobbying on broad science funding issues;
- Introduction of forums, deletion of Cocktail party and moving dinner to Parliament House; and
- Expansion of the concept of 'meeting Parliament' to include policy researchers and support staff for Parliamentarians, Parliamentary Committees and the Department of the Parliamentary Library.

SmP 2005 At A Glance

Participation of scientists and technologists was very strong and easily surpassed all previous SmPs. Indeed, such was the demand, registrations were closed nearly a month before the event (the first time this has been done).

- Participation of Parliamentarians was strong.
- The hypothetical has influenced the national debate on Australia's preparedness to deal with a viral pandemic.
- Both the dinner and National Press Club lunch were very well attended and easily surpassed previous SmPs.
- Changing the dinner from the second to the first day and shifting it to the Great Hall was successful with 81% of both full registrants and PhD/Postdocs attending the dinner.

SmP 2005 At A Glance	
Participating Parliamentarians	142
Total Participation by scientists, technologists and sponsors.	316
Registered for meetings	211
Total number of meetings	144
No. at Dinner	310
No. at National Press Club lunch	270
No. at 'Science for Breakfast'	46
No. at forums at APH	280 (approx)

- SmP has created international interest and this year a delegation from Korea, including 5 Parliamentarians and 3 members of the Korean Science Foundation, attended to observe SmP.

Financial Statement

Income and expenditure were both higher for SmP 2005 than in previous years. The higher income reflects;

a) stronger sponsorship, and
b) marked reduction in complementary tickets.

The increased expenditure is a result of;

a) moving the dinner from Old Parliament House to the Great Hall,
b) substantial increase in numbers attending the dinner; and
c) significant financial investment in hypothetical.

SmP 2005	Debit	Credit
Income		
Delegate Registrations	($740.00)	$41,195.08
Sponsorship (16 groups)		$79,000.00
additional SmP Dinner	($327.27)	$981.82
	($1,067.27)	$121,176.90
	Net Income	**120,109.63**
Expense		
Bank and Bankcard Fees	(479.63)	$0.00
Venue - SmP Dinner	(5,454.54)	$0.00
Briefing Day NPC lunch and hire	(12,800.00)	$0.00
Cocktails-sponsor	(629.09)	$600.00
SmP Breakfast APH	(2,243.63)	$0.00
SmP Lunch APH	(2,623.18)	$0.00
SmP Dinner Great Hall, APH	(37,545.34)	$0.00
Other Event Admin.	(9,608.32)	$0.00
Conference Folders	(500.00)	$0.00
Speaker's Travel	(2,656.99)	$0.00
Board Travel	(1,969.93)	$0.00
Speaker's Accom.	(315.91)	$0.00
Board Accom.	(1,756.28)	$113.64
Salaries & Wages	(39,016.85)	$0.00
Staff Amenities	(15.36)	$0.00
Postage & Stationary	(247.44)	$0.00
Printing & Photocopying	(2,766.77)	$0.00
Web Assistance & Hosting	(1,576.82)	$0.00
	(122,206.08)	713.64
	Net Expenses	**$121,492.44**
Net expenses	**$123,273.35**	
Net income		**$120,823.27**
Profit/(loss)		**($1,382.81)**

Participated in meetings	73
Participated in meetings and attended dinner	50
Attended dinner only [1]	6
Advisors participated in meetings in lieu of Parliamentarians	9
Participated in hypothetical and labour market forum only	4
Total participation	**142**
Did not participate	**83**
Total Parliamentarians	**225**
% Participation	**63.11%**

Participation in SmP

Year	1999	2000	2001	2002	2003	2005
Parliamentarians (226 total)*	139	165	142	130	151	142**

Participation in SmP

Year	1999	2000	2001	2002	2003	2005
Scientists	175	187	186	162	260	316

The net result shows a small loss, however, previous SmP budgets had not properly accounted for the true costs to FASTS of organising SmP notably office wages.

Participation – Parliamentarians

Data reported for all previous SmPs have not been corrected to take account of cancellations that always occur in the final day or so, thus overstate actual participation. Therefore SmP 2005 would seem to have achieved at least the 2nd highest number of participating Parliamentarians.
* *There were 225 Parliamentarians at the time of SmP 2005*
** *Data corrected for cancellations.*

It is worth noting there was a comparatively high level of Parliamentarians unavailable for SmP. The seat of Werriwa was vacant due to the resignation of Mark Latham. In addition, there were at least nine other absentees including:

- 3 on maternity leave;
- 3 on medical leave; and
- 3 were overseas or interstate.

When these are taken into account 66% of available Parliamentarians participated.
On Monday 7th, the President and Executive Director addressed a private meeting of the *House of Representatives Standing Committee on Science and Innovation* for an hour. Seven of the ten committee members attended, including the Chair and Deputy Chair. One committee member who attended the meeting did not participate in any other SmP activities.
FASTS do not have accurate data on attendance by Parliamentarians in the forums. There were at least 3 at the climate change forum and 5 at the hypothetical (in addition to participants). One of these did not participate in other SmP events.
There were 13 meetings with advisors – 10 Ministerial Advisors, 2 Shadow Ministers' advisors and the portfolio advisor for the Democrats.[2]

Participation – registrants

There were 211 registrants for meetings with Parliamentarians (including 37 sponsor nominees). There were 32 registrants who self-identified as PhD and ECRs – a lower figure than expected.
There were 310 bookings for the dinner including 56 Parliamentarians and 4 advisors.
There were 270 attendees at the National Press Club lunch (not including media and NPC Board members).
The total number of registrants, sponsor nominees and industry attendees in SmP were 316 (not including those from CRCs, Land and Water, AFFA and several bio-medical groups who attended the forums).
SmP 2005 is by far the biggest SmP in terms of participation by scientists, technologists and industry representatives.

Meetings

There were 147 meetings organised for SmP. Three were held on Monday 7th, three on Tuesday 8th the rest on Wednesday 9th.
Despite the last minute cancellations and time changes, we were able to ensure that 96% of registrants had at least two meetings. 28 registrants had 3 meetings, 16 only had 1 meeting. 8 of those only got one meeting because 4 presented at forums, 3 were executive members and 1 was only available for a restricted period in the morning, thus only 8 'conventional' registrants did not get two meetings: An excellent outcome given the number of participants and the unavoidable problem of last minute changes to times and cancellations.

Sponsors

There were 16 sponsors for this years SmP realizing $79,000. The sponsors were: (new sponsors in italics)

DEST	Academy of Science
ARC	Biotechnology Australia
NHMRC	ATSE
InnovationXchange	*Michael Johnson and Assoc*
CSIRO	Go8 Universities
Medicines Australia	NTEU
Australian Computer Society	*Bio21*
ATN Universities	*Research Australia*

Ancillary Events

Forums

The three forums at Parliament House were well attended with about 20 at the labour market forum, about 135 at climate change and 125 at the hypothetical. There were 2, 3 and 5 Parliamentarians respectively in the audience plus an unknown number of Parliamentary advisors and researchers (at least 12 at climate change and at least 20 at the hypothetical).
The hypothetical was very successful in terms of the quality of panellists, quality of information and discussion and above all else, its capacity to seriously engage the attention of a senior Minister and Shadow Minister.
The hypothetical has been highly influential in shifting the debate in the media from international stories about avian-flu and WHO commentary to

	climate change	national water initiative	Commercialisation	education and training	salinity	Developments in agri/aqua-cultural science	Invasive species*	sustainable energy	sustainable urban and coastal d'ment	substance abuse and suicide
scientists	38	32	62	95	12	37	6	30	13	7
Parliamentarians	33	33	20	25	16	9	10	32	25	20
	aging productively	cutting edge	new developments in manu R&D	nuclear science	healthy start to life	basic research	natural resources	international collaboration	other	Total**
scientists	25	41	16	13	18	101	26	54	na	626
Parliamentarians	21	8	12	16	4	7	8	10	36	345

addressing Australia's preparedness for a pandemic. FASTS note the 2005/6 budget included increased funding to enhance Australia's diagnostic capacity for a flu pandemic which is a result of the hypothetical.
Biotechnology Australia presented a forum called *Understanding the Drivers of Public Concern: a case study based on understanding and attitude to stem cell applications* at the NPC on Tuesday 8th of March. This was a concurrent session for people who had attended SmP before and therefore were not required to attend the main afternoon session presented by political and lobbying advisors. About 25 people attended and the quality of questions and discussion was very high.

Science for Breakfast

This was a smaller event than in 2003 because fewer PhD/Postdocs registered. 31 people registered prior to the event. An additional 5 signed on at briefing day and 9 advisors/researchers attended.

Topics

(see tablebove, this page)

* *Invasive species aggregated with agri and aqua-cultural sciences in registrants choices – disaggregated here on basis of description of work*

** *Both registrants and Parliamentarians could choose multiple topics*

It is important to note the major mismatch of 'supply and demand' on a number of these topics. This created major difficulties maximising quality of the meetings.

Feedback

As part of SmP, FASTS asked scientists and Parliamentarians to fill out an evaluation form. The response rate was low and thus is not statistically useful (we have received more e-mails from participants than filled out the evaluation form and these, with one exception, are unreservedly positive).

Scientists

Question	Average score
Rating overall success	6.13
Use of briefing day	5.93
Rate meetings: No. 1	5.06
Rate meetings No. 2	5.69
Rate forums	5.4
Rate dinner function	6.2

Parliamentarians

Question	Average score
Rate meetings	6.1
Rate documentation	5.4
Rate dinner	6.3
Rate forums	6.5
Overall success of SmP	6

Perhaps the only interesting thing in the statistics is the different rating between 1st and 2nd meeting from the scientists, which may indicate something about their greater ease or changed expectations although it is unwise to over-determine any statistical information.
The data from Parliamentarians is not particularly useful as vast majority will never put adverse comments or scores in writing.
In summary, the qualitative feedback from scientists was very positive with various people commenting on how well organised SmP was this year.

Additional informal comments from parliamentarians

I have spoken informally with about 15 Parliamentarians face-to-face since their meetings or forums and have received more than 25 e-mails, letters and phone calls from Parliamentarians and a number of senior staff.
The vast majority of commentary has been highly favourable. Four Parliamentarians have indicated they will be following up with all three of the scientists

they met (and FASTS are aware this has happened in at least three of these cases).
Nearly all commented specifically on the quality of matching interests and expertise and how it was better done than in previous years.
A number of comments from Parliamentarians and staff on the quality of the PhD and ECR participants – the 'shone', "they were wonderful, so enthusiastic".
By way of contrast, three commented adversely on older participants: 'Dead wood', 'boring'.
Two commented on the naivity of political arguments on career pathways "why complaining about Govt - what role institutions and their culture?"
I have had a number of comments about the forums. While most were positive, concerns were raised by late starts to both the labour market and climate change forum (although in the case of the Labour market forum it was delayed because Parliamentarians were late).
We received a number of very favourable comments on the hypothetical from Parliamentarians and several requests from advisors/researchers/medi wanting transcripts.
Lots of favourable comments about the dinner both during and after – only complaint raised being Kovac speech far too long.

Bradley Smith
Executive Director FASTS
June 2005

(Footnotes)

[1] The number of Parliamentarians at the dinner may not be exact. There were at least two 'no shows' although, on the other hand, there were three Parliamentarians who turned up with out having RSVP'd.

[2] The 4 meetings with staff additional to the 9 recorded in the chart comprise 2 meetings with advisors in addition to the Parliamentarians' participation and 2 separate meetings with advisors for 2 Ministers unable to participate.

Position Vacant
Australian Optical Society Newsletter

Editor

The AOS is seeking an editor for the newsletter. This is a quarterly publication conveying optics news, scientific articles and optics advertising to the Australian Optics community.

The editor will be paid an honorarium of $2000 p.a or $500 per issue.

Applications and enquiries for this position should be addressed to the President of the Society, Dr Murray Hamilton

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Wanted!!

High resolution Colour Photos and Graphics for AOS publicity purposes (including the front cover of AOS News).
Please email these to the editor murray.hamilton@adelaide.edu.au

NB if the file is larger than 10MB, please first email a warning that the file is on its way!

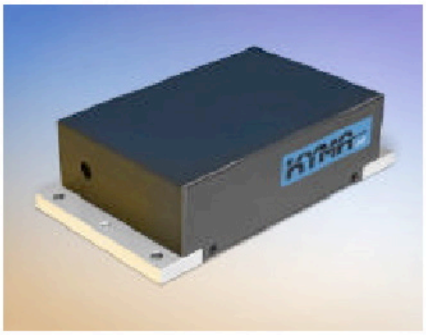
(This gives me time to clear my spam folder and make room on the server - Ed.)

The LASTEK

New Product Information Alert

*"Si adminiculum supernumerarium deest, radius lasericus nugatorius fit, ab universis repudiatus. Non adhibetur, et occasio frustrata quasi longam et amaram umbram proicit."**

Stop the Presses: New from Lastek, your photonics technology support organisation



Melles Griot: New 488nm DPSS Laser

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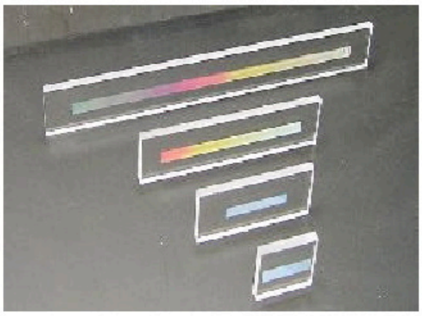

QPS Photronics: FBG technology transfer

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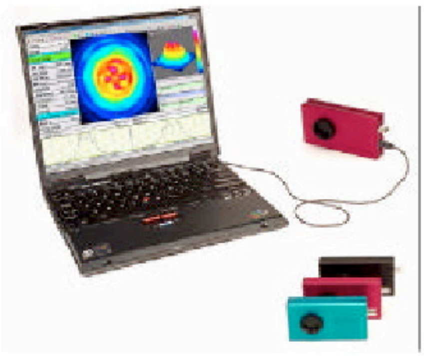

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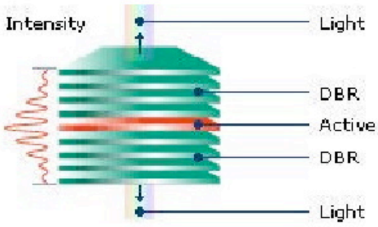

Schematic VCSEL structure

Vertilas: VCSEL laser diodes

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**from page 1:*

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- Attributed to Alessandro Sforza, Ravenna, 1463

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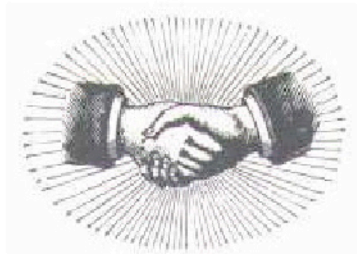

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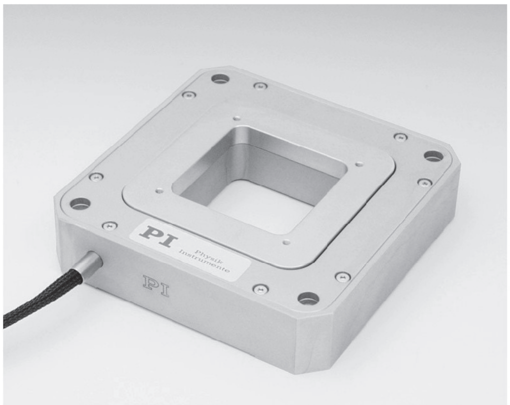

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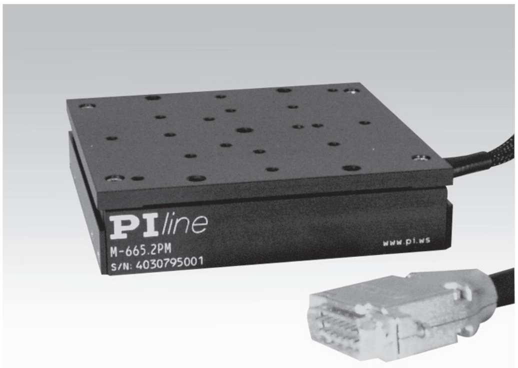

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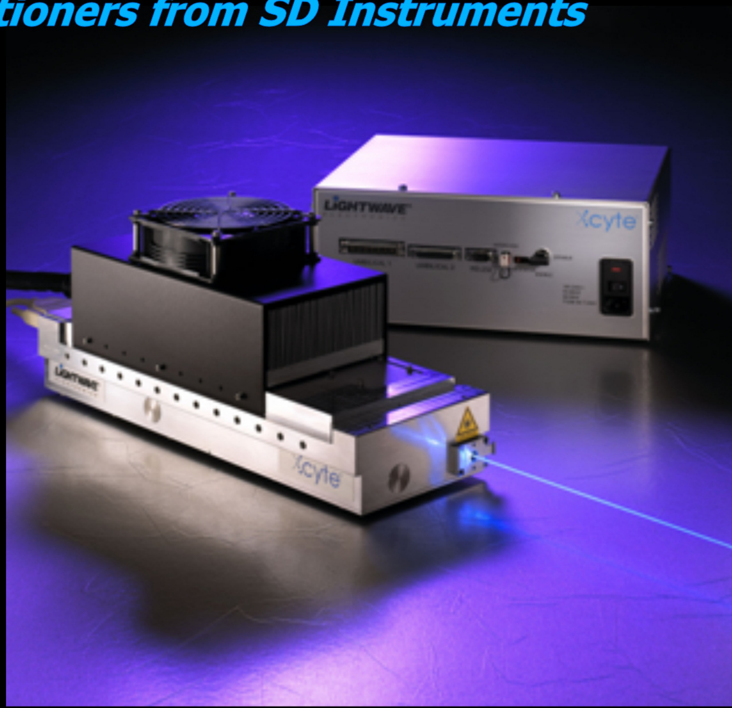

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