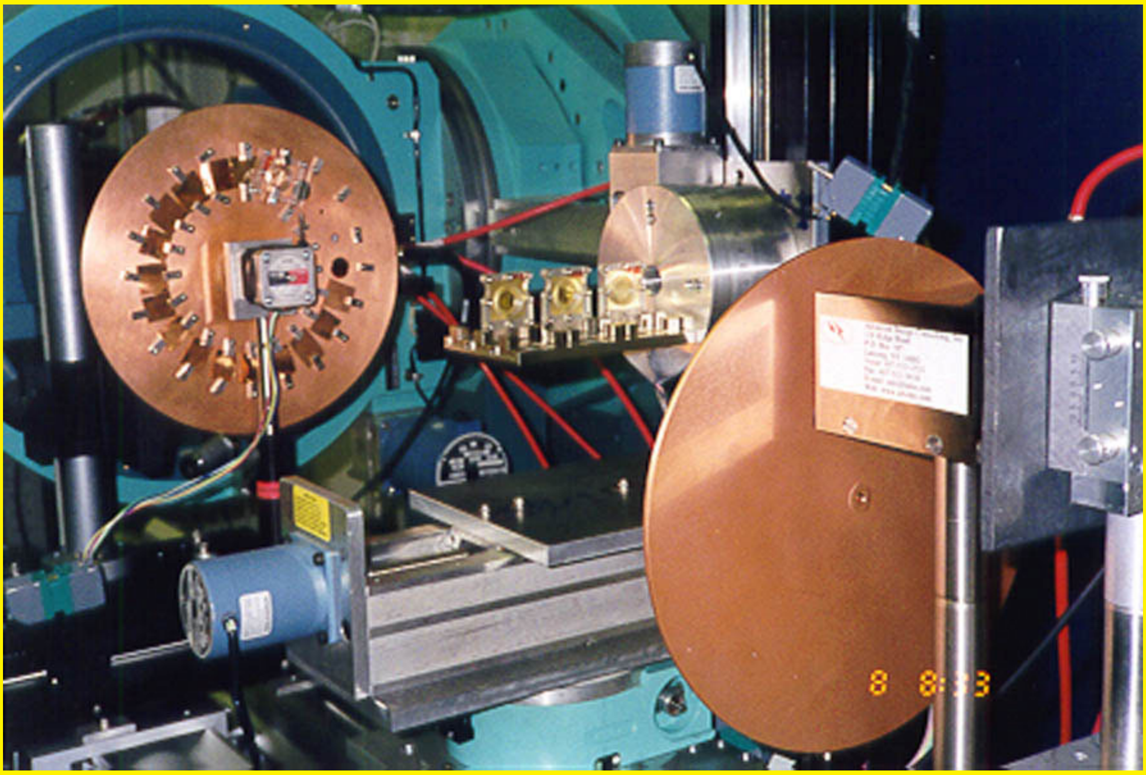
Australian Optical Society
NEWS



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Laser Beam Measurement

gentec-eo
www.gentec-eo.com

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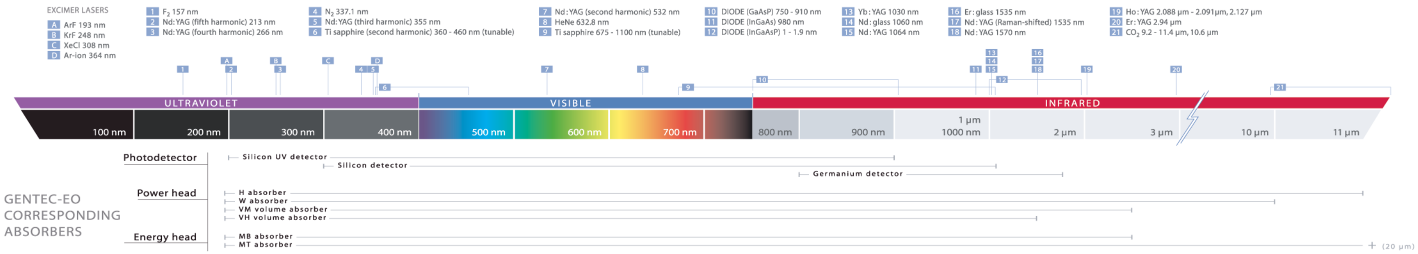
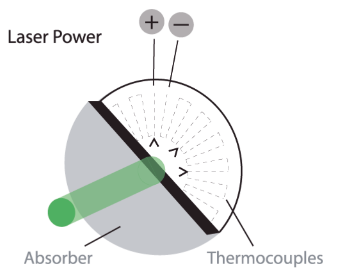


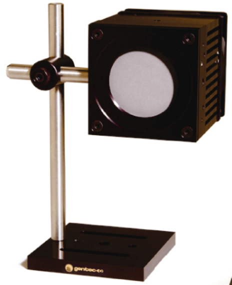
High energy laser calorimeter from gentec-eo
Photo courtesy of Lawrence Livermore National Laboratory

How they work?

Power detectors

- Laser heats absorber
- Thermopile generates voltage proportional to the temperature difference between cold heat sink and hot absorber
- Average voltage is proportional to the temperature difference and proportional to the laser power





Monitor

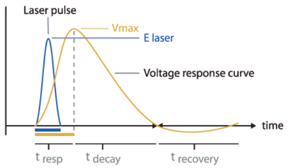
Measure power in 6 easy steps

1. Check that the laser is within the specifications of the detector (power density, energy density)
2. Put the detector in position and turn on the monitor
3. Select the wavelength in the monitor's *Settings* menu
4. With the laser off or blocked, do a zero offset with the monitor's *Ctrl* menu
5. Turn on the laser and let the detector stabilize in temperature for 1-2 min.
6. Make the measurement

How they work?

Energy detectors

- Pulse of light heats absorber
- Pyroelectric detector material generates voltage pulse when shocked by pulse of heat
- Peak voltage is proportional to laser energy



Typical voltage response of a Gentec-EO energy detector.
Rise time
Laser pulse duration
* *Laser pulse duration should be shorter than 75 % of the detector rise time.*

Measure energy in 4 easy steps

1. Check that the laser is within the specifications of the detector (energy density, repetition rate)
2. Put the detector in position and turn on the monitor
3. Select the wavelength in the monitor's *Settings* menu
4. Make the measurement (no need to stabilize detector temperature)

Useful tips

- Do not touch absorber surface with fingers. Contamination can damage calibration and surface.
- A larger beam improves the measurement accuracy.
- Detector may become hot. That is normal as long as it operates below maximum rated average power.
- Use test targets (or test slides) provided with all Gentec-EO energy detectors to make sure the laser will not damage the detector surface.
- Low power measurements with thermopiles (<100 mW) may be sensitive to thermal noise in the environment. Shield detector from external light source, your body, and other thermal sources.
- A power detector can make single shot energy measurements with the monitor set to energy mode.
- When using volume absorbers, put the detector at a slight angle in order to avoid back reflection into the laser.

lambda scientific

Experimental Instruments

LEOI-100 Multi-channel Optical Analyzer

LEOI-100 Multi-channel Optical Analyzer is a general purpose experimental instrument. It uses CCD as receiver, capable of real-time acquisition and 3-dimensional display. It is an ideal equipment of spectra measurement

Specifications

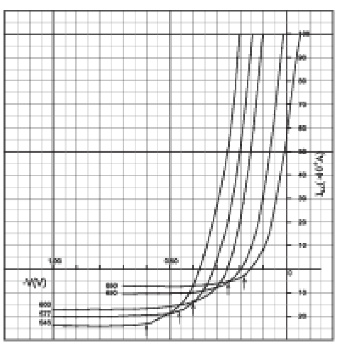
Wavelength Range	300 ~ 800 nm
Focal Length	302.5 mm
Relative Aperture	D/F=1/7
Resolution	≤ 0.2 nm
Wavelength Accuracy	≤ ± 0.4 nm
Wavelength Repeatability	≤ 0.2 nm
Stray Light	≤ 10^{-3}
Slit Width	0 to 2 mm, adjust., 0.01mm

Experiment examples

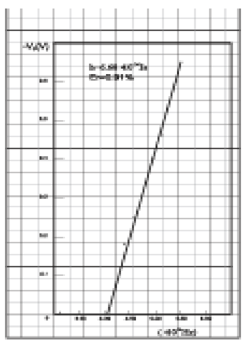
- Observe Atomic Emission Spectra
- Calibrate the CCD Grating Spectrometer
- Measure the Rydberg constant

LEDI-1 Planck's Constant Measuring Unit

LEDI-1 is an instructional instrument used to determine the photocathode's I-V curves at different frequencies. It can be used to validate the Einstein equation and further determine the Planck's Constant



Approximate *I-V* curve indicates the photocathod's volt-ampere characteristics



Vo-v Diagram and the obtained Planck's Constant

Specifications

Light Source	Bromine Tungsten Lamp
Condenser	f = 50 mm and 70 mm
Photocathode Tube	Mode GD31
DC Reg. Power Supply	± 1.8 V, digital display
Measuring Amplifier	4 stops, current amplified
Monochromator	Ruled Grating
Wavelength	200 ~ 800 nm
Slit Width	0.3 mm
Wavelength Accuracy	± 3 nm
Wavelength Repeatability	± 1 nm

Lambda Scientific Pty Ltd
2/147, Buxton Street, North Adelaide SA 5006 Australia
Phone: +61 8 8267 2686
Fax: +61 8 8267 2689
E-mail: sales@lambdasci.com

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.

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COPY DEADLINE
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EDITOR (acting)
Murray Hamilton
The University of Adelaide
Physics Department
Adelaide SA. 5005
Tel: (08) 8303 3994
Fax: (08) 8303 4380
murray.hamilton@adelaide.edu.au

Australian Optical Society website

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

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September 2006 **Volume 20 Number 3**

AOS NEWS

ARTICLES

Regular Articles

DEPARTMENTS

Cover Picture: A typical experimental arrangement used to employ the x-ray extended-range technique (XERT) to measure mass attenuation coefficients almost two orders of magnitude more accurately than any previously reported in the literature. More details are to be found in the article on page 30.

AUSTRALIAN OPTICAL SOCIETY

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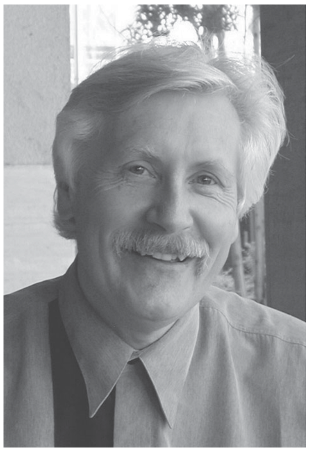
President's Report



Dear colleagues

Taking on the role of president of the Australian Optical Society gives me the opportunity to contribute to our profession and to help to make the AOS relevant to you and everybody who works in optics in our region. First let me thank the leadership team of Murray Hamilton, John Holdsworth and Steven Collins who have done a great job over many years to run such a well organized and smoothly functioning association. The conferences supported by AOS are well received, ACOLS, ACOFT and our participation in the AIP congress are highly regarded as scientific meetings. We are planning to concentrate our future conferences on these main events, typically once a year, in order to create meetings which are well attended and provide opportunities for networking at all levels.

I see it as a challenge for the future to achieve an even wider representation in AOS of all people working in optics. For example we need to ensure that the optical and photonics industries, which are fortunately expanding again, see AOS as their professional association. At the same time we want to intensify our links with New Zealand, as discussed on our last AGM. We already have some good links as the last ACOLS in Rotorua has demonstrated. However, our goal is to show that the AOS can play an important role for optics in both countries. To have John Harvey from Auckland now as a council member is one first positive step.

In our general society, with its many competing interests, there is a need for effective professional associations, for lobbying and for a groups that take a long term view and have some stable resources. While this role is important, the major goal for the AOS will remain to keep the young generation involved. Societies such as the AOS are normally not cool, they represent an aspect of our society which is dealing not with fun issues but with those that are rather formal and dull. Have you recently talked to your students and younger colleagues about the advantage to join professional associations or unions ? Have you found ways of sharing the enthusiasm and fun we all have with optics and physics through an association such as ours? Let us share such ideas and let us all try to make the AOS more attractive to young people.

I wish you great success with your work in optics.

Hans Bachor
President, Australian Optical Society
August 2006.

Department of Education Science & Training (DEST) French-Australian Science & Technology (FAST) program and Australian Research Council (ARC) Australian Research Network for Advanced Materials (ARNAM) presents

1st International Workshop on Multiphoton Processes in Glass and Glassy Materials

Darlington Centre, University of Sydney, Sydney, Australia, **Dec 11-12 2006**

(Sponsors: CUDOS, Raymax Applications Pty Ltd and Time Bandwidth Switzerland)

Multiphoton processes are initiated by high intensity laser light, increasingly operating in the femtosecond domain. Applications extend from simple material processing, microfluidic channel formation and waveguide manufacture to photonic bandgap structures in 1, 2 and 3 dimensions. Processing of silica remains particularly relevant, although other glassy systems are increasingly attractive. The processes underpinning excitation deep into the band edge of a material remain complex and are the subject of intense research. This workshop brings together experts in the field for the first time to debate and discuss these processes and how they can be exploited to further utilise and optimise the multiphoton approach to optical engineering of materials and devices.

A particular ambition of this workshop is to expose Australian students and early career researchers working in this field to the latest thinking from around Australia and the world, as well as provide an opportunity to network and link up with the groups leading the way in multiphoton processing.

The workshop is an advanced specialised workshop and the audience numbers will be capped to 50. Expression of interest for attendance are sought in the first instance from those who work in the field or work in applications that make use of such technology. Remaining seats will be generally open. *More information: j.canning@oftc.usyd.edu.au*

Australian Institute of Physics (AIP) 17th National Congress
3 – 8 December 2006

Brisbane Convention and Exhibition Centre, Queensland, Australia

The Australian Institute of Physics (AIP) National Congress is held approximately every two years and is the largest and foremost national conference for physicists in Australia. The Congress is composed of Plenary Sessions of general interest, and meetings of the topical groups of the Australian Institute of Physics as well as affiliated societies. The program is developed through a Program Committee constituted by local members of the topical groups and affiliated societies. The theme of the meeting will be RiverPhys, celebrating a meeting that will facilitate the presentation of contemporary physics research in Australia, on the banks of the beautiful Brisbane river.

We are delighted the following distinguished plenary speakers have accepted invitations to speak at the Congress:

Professor Sandra Chapman - Head of the Space and Astrophysics Group, University of Warwick, United Kingdom

Dr Pierre-Gilles de Gennes (1991Nobel Prize in Physics) Institut Curie, Paris, France

Professor Athene Donald - Cavendish Laboratory, University of Cambridge, United Kingdom

Professor John Hall - University of Colorado, JILA; National Institute of Standards and Technology Boulder, USA *Professor John Hall is the winner of the 2005 Nobel Prize in Physics.*

Professor Sir Chris Llewellyn Smith, FRS (Director of UKAEA fusion program and the Joint European Torus) Culham Science Centre, England

Professor David Southwood - Director of Science European Space Agency, United Kingdom

Dr Eric Mazur (2001 NSF Director's Distinguished Teaching Scholar Award) Division of Engineering and Applied Sciences, Harvard University, Cambridge, USA

Professor Michael Wiescher, (2003 Hans Bethe Prize), Director of the Joint Institute for Nuclear Astrophysics Department of Physics, University of Notre Dame, Notre Dame, USA

Professor Joe Wolfe, (2004 International Medal of the French Acoustical Society) School of Physics, University of New South Wales, Sydney, Australia

Professor Anton Zeilinger (2000 Senior Humboldt Fellow Prize) Institute of Experimental Physics, University of Vienna, Austria

For more information please visit www.aipc2006.com

CUDOS Student competion

The ARC Centre of Excellence CUDOS recently ran a student competition where students had to describe their research in terms accessible to lay-people. We publish some of the entries in this issue of the AOS News.

Music of the Spheres

Peter Domachuk, University of Sydney

Picture this: You are standing on the edge of a chasm that rends the otherwise featureless plain surrounding you asunder. It's not particularly wide (you can see the other side) but, like a terrifying crevasse in glacial ice, you can't see the bottom for its dizzying height. Suddenly, a huge beam of light erupts from these murky depths (think "Independence Day" alien death ray). Emerging from the abyss, riding the beam of light, is a giant glass sphere. Its coming for you quicker and quicker and, just as you think it's about to fly into space it stops dead in its tracks and just hovers in front of you. Then it starts dancing….

The description above sounds like something from a stark science fiction vision of some alien planet, flung far into the future and the distant reaches of the universe. Yet it's happening right here on earth. "Ease up on the Peyote," you may be thinking, "there's no such thing as tractor beams that can suspend giant glass spheres at great heights!" Well if in the above scenario you are the size of a photon (1/100 the width of human hair) that is exactly what you would see in a new device that utilizes a thirty-year old phenomenon to uses light to control light.

At the CUDOS Centre based at the University of Sydney, we are interested in light: specifically we are interested in controlling light and making it go places and do things that it might not otherwise do. I am part of a team that built the device described above that uses a light beam to levitate and hold a glass sphere 1/5 the width of a human hair. Why would I want to do this? Well the glass sphere acts like a lens and, once it is held firmly by the beam of light, I can move it around by changing the position of light beam that is holding it. The focusing properties of the sphere means I can image parts of the micro world and, further, I can manipulate beams of light in this micro world (other than the one holding the sphere) all without actually touching anything. Light controlling light…..

The phenomenon I'm utilizing to levitate and control the sphere is called "optical trapping" and was discovered in 1976 by Dr. Arthur Ashkin from Bell Laboratories. An optical trap is basically a laser beam, strongly focused using a microscope lens. The shape of a focused beam is kind of like an hour-glass: as it emerges from the microscope lens, it shrinks down to its smallest point (the beam waist) after which it expands again. When a small particle, like our glass sphere, gets near the beam it feels a force pulling it into the beam waist. Once there, these same forces hold the sphere in a stable way, meaning that if the sphere tries to escape it is pulled back into the waist of the beam. Just like the tractor beams from science fiction. Once the sphere is held in the optical trap, it is a simple matter to move it around. All I have to do is change the position of the trapping beam waist and the glass sphere obediently follows.

So now I have a levitating glass sphere at my command, what shall I do with it? As I mentioned earlier, at CUDOS we like controlling light. So what I do is bring my sphere near the end of an optical fiber: long thin glass "wires" used for transporting light. The beam of light coming out of the end of the fiber is spreading rapidly. Remember that the glass sphere acts like a lens? With the sphere positioned on the end of the optical fiber the beam is now brought to a focus. Furthermore, I can make the sphere "bob" from side to side and in doing so I can control where the focused light from the optical fiber lands. Light controlling light ...

This demonstration of optical trapping I've described is a very basic one, but the idea of using optical traps to manipulate things in the micro world is very powerful. Already scientists routinely use this technique to manipulate cells, sort them, hold them, rotate them even perform surgery on them, all without touching them. I hope that this demonstration will lead to further work where independently trapped objects will interact on a microchip, performing a large number of functions combining light, electronics and maybe even biological matter and fluids. The sky is the limit when you're able to levitate.

(*This was the winning entry Ed.*)

An Explosion of Colour

Dane Austin, CUDOS, University of Sydney

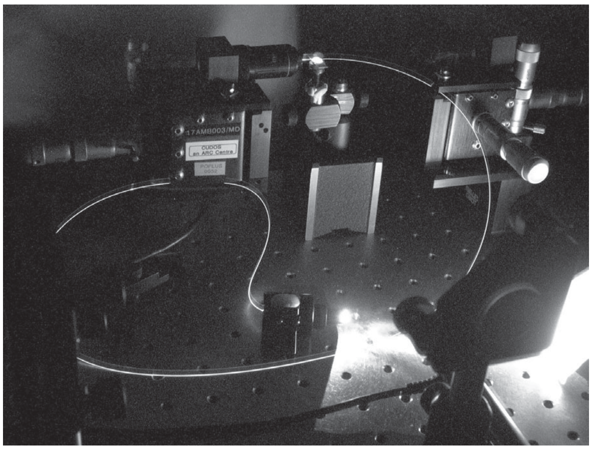
In the darkness of my laboratory, a labyrinth of mirrors directs a laser beam through a complicated series of lenses and prisms. The beam is intense enough to ignite paper and yet completely invisible – its colour is outside our narrow range of vision. By adjusting one of the mirrors I focus the beam on an optical fibre – a glass 'tube' one thousandth of a millimetre in diameter. Suddenly the room is illuminated in brilliant white light! The laser beam has undergone an amazing transformation from invisibility to spanning all colours in the visible – hence its white appearance. The effect is called supercontinuum generation, and my colleagues and I create and observe supercontinuum on a daily basis, seeking to understand its properties and realize some of its many potential applications.

The most important ingredient in supercontinuum generation is an extremely intense light field. I achieve such fields by focusing a laser beam down to a small area, in the same way you would ignite paper using the sun's rays and a magnifying glass. However, by focusing the beam onto the microscopic core of a glass optical fibre, I can 'trap' it and maintain this tight confinement for long distances. It is the effect of this powerful field on the electrons in the glass that generates supercontinuum. Imagine a small boat anchored to sea floor. In a light swell, the small waves exert gentle forces on the boat, resulting in a smooth back-and-forth motion. Compare this to a vile storm, during which the boat is mercilessly shaken, straining and jerking on its anchor. In the glass optical fibre, the electrons behave like our boats, tightly anchored to the nuclei of their atoms, whilst the intense laser field is like a passing storm as it careens down the fibre's length. The shaken electrons, straining on their bonds, act as miniature antennae and release light at a colour which depends on the intensity of the laser. This is radically different from the relatively weak light sources (e.g. normal daylight) to which we are accustomed, where the gentle electronic forces do not affect the colour of the emitted light. The end result of this maelstrom is that white light, the combination of all colours, emerges from the fibre. Using mirrors we can direct this light to various devices for study or application.

Supercontinuum generation is unique in providing a laser-like source of white light. The laser was one the most important technological developments of the twentieth century because of its ability to produce streams of essentially identical photons (the fundamental particles of light). Like an army of well disciplined soldiers, the photons all move in the same direction in perfect synchrony, producing an intense, well directed beam. In addition, the photons are of identical colour. Whilst these characteristics give lasers a plethora of applications, there are many situations where it is desirable to broaden the range of colours without sacrificing the other laser properties. In these situations, supercontinuum is ideal. Today, for example, I direct the white light through a new type of optical fibre with the potential to improve long distance telecommunications. By comparing the beam before and after the fibre, I can infer its transparency – an essential property for communications fibres. However, the most important current application of supercontinuum generation is to a seemingly unrelated area – the measurement of time.

Ever since Galileo Galilei used his heartbeat to time the swing of a pendulum, producing accurate clocks has been a goal of science. As our understanding and technology have improved, physicists have been able to measure time to ever greater levels of precision. For extremely short events, such as the incredibly rapid oscillations of the electric field in light, it is more convenient to measure the frequency – the number of oscillations that occur each second. For visible light this is about 10^{14} cycles per second. Such rapid variations are of course far beyond the range of our relatively ponderous senses – and, as it turns out, far faster than any machine we could build to count them directly.

However, if a known reference is available, we can measure such frequencies using a simple trick. As is known to any musician, if a tuning fork is sounded alongside a slightly out-of-tune instrument, a warbling beat tone is observed. The beat tone, at maybe a few beats per second, is much easier to count that than the instrument's frequency (hundreds of cycles per second). The instrument's frequency can then be inferred from the beat tone using the known tuning fork as a reference. Exactly the same principle applies to the measurement of optical frequencies using



Above: Supercontinuum generation in an optical fibre – the (invisible) laser beam is incident from the left, and as the beam moves through the fibre, new colours are generated until white light emerges.

supercontinuum generation. Since the colour of light is determined by its frequency, the many colours of the supercontinuum each act as miniature tuning forks, each with precisely known frequency. An unknown laser source can produce a beat tone with one of the 'tuning forks', allowing extremely accurate measurement of the frequency. Such techniques have more than academic interest; accurate clocks are the basis of Global Positioning Systems. In addition, Einstein's General Relativity predicts that the frequency of light is changed very slightly by gravity, so that by measuring the frequency shift it is possible to infer the strength of gravity at a particular location. Whilst our Earth has a roughly uniform gravitational field, its strength changes imperceptibly as a result of nearby geographical and subterranean features – ocean currents, molten rock flowing under the crust and large mountain ranges. Physicists hope to use supercontinuum generation to build accurate detectors that will 'map' the Earth's gravity field, helping to discover buried minerals and study ocean current changes driven by climate change.

Momentarily dazzled by the brilliant beam emanating from my lab bench, it is hard to imagine the far reaching consequences of something as basic as white light. Yet, by combining a great nineteenth century invention – Edison's white light bulb – with the twentieth century advent of the laser, supercontinuum generation will prove to be a very useful tool for the twenty-first.

Smart Gemstones

Luke Stewart, CUDOS, Macquarie University

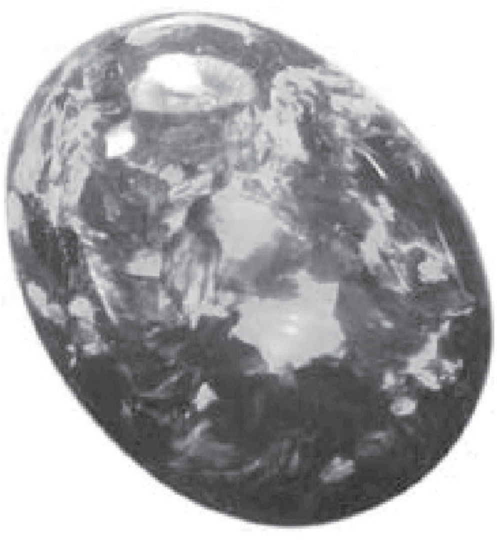
When opals are mentioned, people automatically think of gemstones and jewellery. So, when I was offered a PhD research project based on opals I was more than a little sceptical. Did I really spend all this time at uni to get a degree in physics, only to become a glorified jeweller? How could I explain this to all my friends? It wasn't until I began doing some research that I realised that there was more to opals than I had ever imagined.

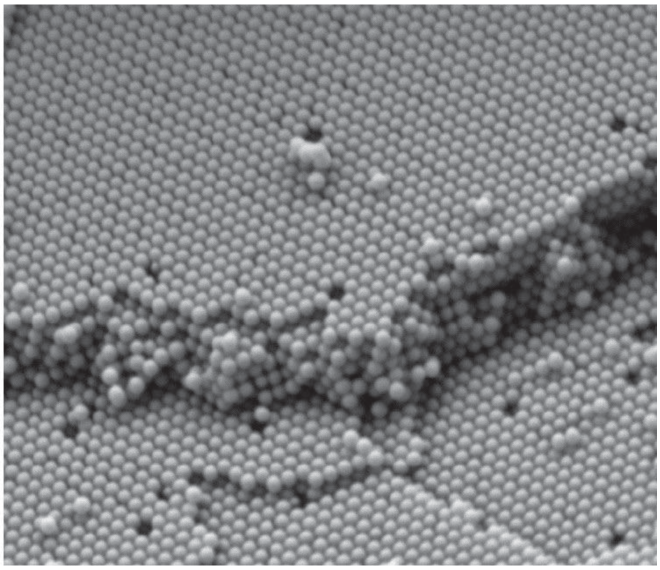
Opals are a naturally occurring gemstone renowned for their brilliant iridescence. This unique and beautiful phenomenon is an example of the opal's control over certain colours of light. For some time, the reason behind this iridescence was unknown, and it took the development of the scanning electron microscope (SEM) to obtain an explanation. High magnification images obtained from SEMs found that precious opals were made up of tiny, uniform spheres of silica, which fit together in an orderly (or periodic) three-dimensional frame. The fact that the opal was arranged into an orderly frame allowed certain colours of light to be highly reflected at specific angles. This gave the opal it's well known iridescence that changed as the gem was rotated.

People realised that it may be possible to fabricate opals in a laboratory, since the basic ingredients was simply a collection of tiny, uniform silica spheres. Also, since these spheres must naturally arrange themselves into an ordered three-dimensional frame to form an opal, they may do the same in a laboratory under the correct conditions. The first synthesised opal was produced in 1974 by Pierre Gilson, and opals are still being synthesised and sold as jewellery today.

In 1987, Eli Yablonovitch and Sajeev John independently suggested the creation of photonic crystals – devices made up of ordered arrangement of glass or plastic components. It was shown that such devices could prohibit certain colours of light from entering. Opals are a prime example of a photonic crystal and for this reason are now of interest to science.

This leads to my project, where I am fabricating opals with the view to studying them as a photonic crystal. To make synthetic opal samples, I start with a solution containing a uniform sample of tiny spheres. The size of these spheres is generally around half a micrometre in diameter, which equates to being approximately 200





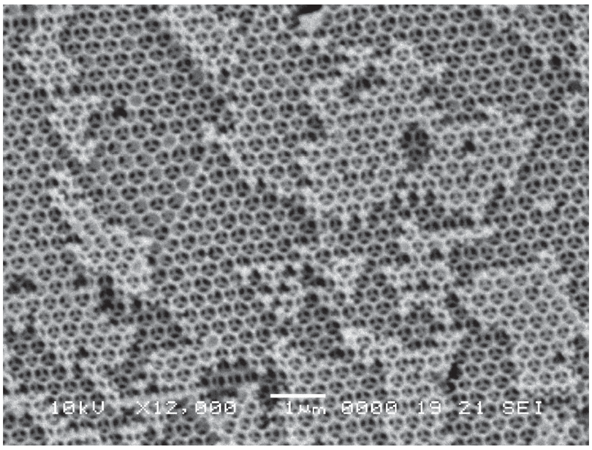
Above Left: An opal gemstone, displaying its brilliant iridescence; Right: An example of a high magnification image of an opal I have made, showing a periodic arrangement of tiny spheres times less than the width of a human hair. As the name "self-assembly" suggests, the organisation of the spheres into a periodic structure is something that occurs naturally under the right conditions. It is up to me to seek out and provide the correct conditions for optimal growth. Under these conditions, a microscope slide placed close to vertical in a solution of the spheres will have an opal film deposited onto its surface as the solution evaporates over several hours. Alternatively, the spheres can be left to settle to the bottom of a vial and assemble under gravity.

There are a couple of differences between natural opals and the opals grown from this method. Firstly, opals used for photonic crystal research are generally in the form of a thin film, rather than a bulk gemstone like the natural opals. Also, while natural opals are made from silica spheres, there are no constraints as to the materials used in synthetic opals. Polystyrene and polymers are some of the more common materials used.

Synthetic opals can also be used as a template to fabricate what it known as an inverse opal. This basically involves infiltrating the gaps between the spheres with a different material. The spheres can then be removed by either chemical etching or heat treatment to leave a structure that is basically the 'negative' three-dimensional image of the original opal, as shown below. By doing this, the conventional opal can be taken to the next level by infiltrating it with more functional materials.

The opals fabricated in my research will improve our understanding of the needs of practical photonic devices. With careful engineering, it is hoped that by understanding the way that opals control light, the same principles can be exploited to guide, filter or trap specific colours of light for applications in communication systems. The long term goal is to make the next generation, all optical processors on a chip. Such a chip would involve light flowing around circuits instead of electrons, and so the problems of heat associated with electronic processing chips would not occur. Thus, the circuits could run at much higher processing speeds, which could eventually make for ultra high speed computing. Photonic crystals would be an integral part of this chip, allowing the light to be moved around the chip in a controlled fashion at a microscopic level.

Knowing what I now know about opals and their potential applications in physics, I realise that I am in an involved in an exciting research topic that is at the cutting edge of photonics research. Nature has provided us with an invaluable insight into how it would create a photonic crystal, and who are we to argue. I only hope that synthetic opals can fulfil their full potential in optical processing, and that one day every household can reap the benefits.



Above: An inverse opal I have fabricated. The spheres are now holes and the original voids are solid. Notice that the structure is still periodic.

SPIE The International Society for Optical Engineering

SPIE was formed in 1955 as the Society for Photo-optical Instrumentation Engineers, and has been dedicated to providing the best possible service to the optical engineering community. SPIE is an international technical society dedicated to promoting the engineering and scientific applications of optical, photonic, imaging and optoelectronic technologies through its education and communications programs, meetings and publications.

SPIE offers

International Networking

Today SPIE is the largest international professional engineering society serving the practicing engineer and scientist in the field of optics and photonics. The Society serves the global technical and business communities, with over 14,000 individual, 320 corporate, and 3,000 technical group members in more than 75 countries worldwide. Advance professionally through networking and visibility among your peers. Learn from others and gain access to the voices, ideas, and the energy of a global community.

Meetings

Among the many services the Society offers are the sponsorship, planning, and execution of technical conferences, product exhibitions, and symposia. SPIE's technical meetings and symposia are internationally-acclaimed gatherings of engineers and scientists working in optics, optoelectronics, and many related fields. They take place in large and small venues, from specialised topics to cross-disciplinary information exchanges, complete with extensive programs including short courses, workshops, and other special activities.

Publications

A major activity of SPIE is the publication and distribution of archival professional journals, full-manuscript conference proceedings, newsletters, and optics-related texts and monographs. SPIE publications deliver timely, high-quality technical information to the optics, imaging, and photonics communities worldwide. Membership includes a subscription to *OE Reports*, a monthly newspaper that provides news and commentary on cutting-edge technology.

and More

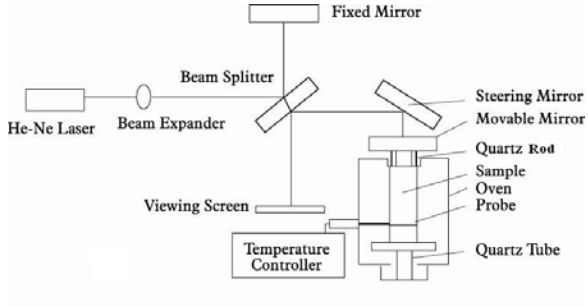
In addition, SPIE provides numerous services to its members, including on-line electronic databases, electronic bulletin board and networking services, and employment assistance. To further serve the public good, the Society sponsors a number of awards, scholarships, and educational grants every year, and publishes a comprehensive catalogue of educational resources in the optics field, *Optics Education*.

To join SPIE: Complete the online membership form at *www.spie.org/membership_form.html*, print and fax it to SPIE along with a copy of your AOS dues receipt. (Be sure to indicate that you are eligible for the US$20 discount as an AOS member). Any queries can be directed to Mr Paul Giusts at *membership@spie.org*

SPIE International Headquarters
Tel: +1 360 676 3290 *Fax*: +1 360 647 1445 *email:* spie@spie.org
web: http://spie.org
PO Box 10, Bellingham WA 98227-0010 USA

LETI-1 Thermal Expansion Experiment Device

This device includes a Michelson interferometer and an electric heating unit. Displacement of the testing sample ends are measured in terms of the number of interference fringes. Therefore, the linear expansion coefficient of the material can be calculated accurately.



Schematic diagram

Specifications

He-Ne Laser	1.0 mW@632.8 nm
Sample	Copper, aluminum and steel
Sample Length	150 mm
Heating Range	18 °C ~ 60 °C
Temp. Measuring Accuracy	0.1 °C
Power Consumption	50 W
Error of Linear Expansion Coefficient	< 3%

LEMI-1 CCD Young's Modulus Measuring System

Young's Modulus, *E*, is a constant that describes mechanical stiffness and is expressed as the ratio of stress to strain of material experiencing tensile or compressive stresses.

This system is designed to demonstrate that the deformation is proportional to the strain in a wire under load which is applied to one end while the opposite end is fixed. A CCD camera comes with the microscope.

Specifications

Stainless Steel Wire	90 cm long, 0.25 mm in dia.
Molybdenum Wire	90 cm long, 0.12 mm in dia.
Reading Microscope	14×, Range: 3mm/0.05mm
CCD Video Camera	Pixel 752(H) ×582(V)
Monochromator	Ruled Grating
Video Monitor	B&W, 35 cm, 75 Ω
Total Magnification	54×
Relative Accuracy	<5%

Lambda Scientific Pty Ltd
2/147, Buxton Street, North Adelaide SA 5006 Australia
Phone: +61 8 8267 2686
Fax: +61 8 8267 2689
E-mail: sales@lambdasci.com

Announcement *Call for Papers*

Advanced Infrared Technology and Applications 2007

Giorgio Ronchi 9th International Workshop (AITA 2007)

AITA 2007 constitutes a forum for bringing together researchers working in universities, industry, and government to exchange knowledge, ideas, and experiences in the infrared science and technology. The workshop will take place at the *Centro de Investigaciones en Optica (CIO)*, in León, Guanajuato, Mexico, October 8 - 12, 2007.

Conference Chair: **Marija Strojnik**, Centro de Investigaciones en Optica; León, Mexico
Co-chair: **Laura Bozzo Ronchi**, Fondazione *Giorgio Ronchi*; Firenze, Italy

Program Committee: **G. M. Carlomagno**, University of Napoli, DETEC (Italy); **C. Corsi**, Alenia-Creo L'Aquila (Italy); **I. Pippi**, CNR-IFAC (Italy); **H. N. Rutt**, University of Southampton (United Kingdom); **O. Salvetti**, CNR-ISTI (Italy); **D. Balageas**, ONERA, Chatillon (France); **T. Bucciarelli**, University of Rome *La Sapienz*a (Italy); **C. T. Elliott**, Heriot-Watt University Edinburgh (Scotland); **E. Grinzato**, CNR-ITC (Italy); **X. Maldague**, Laval University, Quebec (Canada); **T. Sakagami**, Osaka University (Japan); **S. A. Scholl**, Alenka Associates (USA); **J. L. Tissot**, ULIS Veurey Voroize, (France); **V. P. Vavilov**, Tomsk University, (Russia); **H. Wiggenhauser,** BAM Berlin, (Germany); **H. Zogg**, ETH Zurich, (Switzerland).

Areas of interest include Advanced IR**:**

- Technology and materials
- Smart sensors
- Thermofluid dynamics
- Far infrared detectors and technology
- Non-destructive test and evaluation
- Image processing and data analysis
- Systems for cultural heritage
- Biomedical applications
- Environmental monitoring
- Aerospace and Industrial applications

Abstract submission e-mail**:**AITA2007@aol.com
Abstract submission must include the following:
1. Paper title; 2. Authors (first and last names); 3. Institution and Complete mailing address, phone, FAX, and e-mail address, 4. Presentation preference (oral or poster); 5. Principal author's biography (70 words); 6. Abstract (250 words); 7. Keywords (maximum three).

Important Dates:

Conference dates:	October 8-12, 2007
Abstract:	March 30, 2007
4-page summary:	July 1, 2007
Early Registration:	July 10, 2007
IRP&T Manuscript:	Obtober 8, 2007

Paper publication: All papers presented at the conference by the author will be peer-reviewed. Select papers will be published in *Infrared Physics and Technology,* (Elsevier)**.**

Conference Location: León is the fourth largest city in Mexico, situated in the State of Guanajuato, between Mexico City and Guadalajara. León is world-famous for its leather industry. (A pair of fine man/woman´s shoes costs from US$20 to $30.). Only 30 min away, the capital of Guanajuato is considered one of the most beautiful colonial cities in Mexico and has been named *Cradle of the Humanity* by UNESCO. For the last 30 years, this city has been hosting the famous *Festival Internacional Cervantino* (http://www.festivalcervantino.gob.mx) from October 3 through October 22. International artistic and cultural events are presented in its theaters, museums, and open space. Two hours away, quaint city San Miguel de Allende gives home to unique handicrafts in wood, pottery, metal, rocks, and is populated by Americans (30%). In the autumn, the weather cools just enough to walk outside, but sweaters are worn at night.

Housing accommodations (normal price after July 20, 2007)
Prices include tax. Mexico Inn: (http://www.mexicoplaza.com.mx), US$75 suite for 2 people;
Villas Mediterraneas, US$70 for 3 rooms with 2.5 bathrooms, for up to 5 persons, (http://www.villasmediterraneas.com).

Early registration fees: Regular US$300, Student (ID and less than 34 years of age) US$150. **Accompanying person:** US$150

CENTRO DE INVESTIGACIONES EN OPTICA, A.C.

Centro de Investigaciones en Optica
Apartado Postal 1-948
37000, León, Gto, México
Tel: +52 477 441 42 00 ext 156
e-mail:susana@cio.mx (htt://www.cio.mx)

Giorgio Ronchi Foundation

Fondazione *Giorgio Ronchi*
Via S. Felice a Ema, 20
50127, Firenze, Italy
Tel: +39 055 232 08 44
(http://ronchi.iei.pi.cnr.it/AITA2005)

Product News

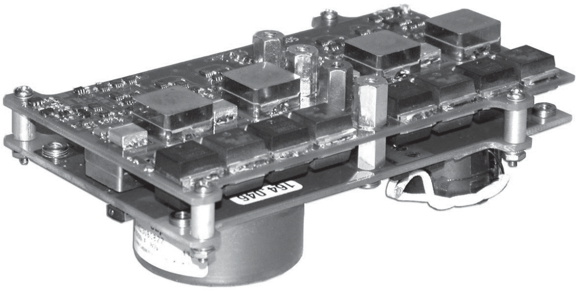
New Laser Diode Driver

Warsash Scientific is pleased to announce the release of Model 772, a pulsed laser diode driver from Analog Modules Inc.

The model delivers 70- to 140-A current pulses with <10-μs rise time into diode stacks of 15 to 24 V at an average power of up to 20 W with >70% efficiency.

Measuring 4.3 x 2.7 x 1.5 in. and weighing <10.5 oz, the polyphase unit provides power and trigger signals for the company's Pockels cell drivers. It can be cooled with natural convection and offers open- and short-circuit and thermal overload protection.

Further information on these and other laser accessories is available from WARSASH Scientific Pty Ltd at (02) 9319 0122 or *sales@warsash.com.au*



New Motion Controller

Physik Instrumente (PI) has announced the release of their new E-761 PCI bus piezo nanopositioning digital motion controller.

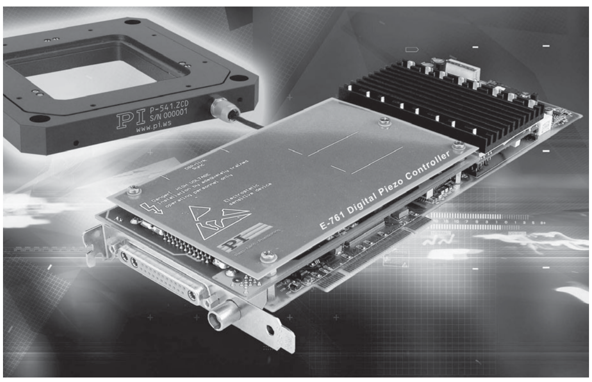
The E-761 PCI controls three logical axes of closed-loop piezoelectric nanopositioning systems with capacitive position feedback.

Its PCI interface provides high-throughput and precise motion synchronisation with frame grabbers and other peripheral devices. The system also has a high bandwidth analogue position control input for external triggering applications.

The four onboard piezo drivers require no external amplifiers.

Features include a 32-bit digital signal processor, 24-bit digital-to-analog converters for subnanometer position resolution, polynomial linearization and coordinate transformation.

Further information on these and other positioning systems is available from WARSASH Scientific Pty Ltd at (02) 9319 0122 or *sales@warsash.com.au*



Revolutionary New Actuator from New Focus

For over 15 years New Focus has been delivering its claim of *Simply Better* products for the photonics industry. With the wealth of design experience that comes from suppling to demanding 24/7 OEM markets, New Focus has sustained this claim by producing high quality solutions for research and industry. High stability and high tolerance mixed with ease of use and simple integration has kept this company at the top for reliable, precision instrumentation.

With the introduction of the *Picomotor*™, New Focus has again revolutionised the actuator/positioning market. The *Picomotor*™ has many unique advantages over the standard micrometer-piezo stack combination.

- Sub 30 nanometre step size across entire travel length (up to 51mm) without the need for separate "coarse" adjustment
- Minimal-backlash design
- No piezo creep
- Position held even with loss of power
- Compact footprint

The *Picomotor*™ comes in a variety of travel lengths, with or without optical encoder, and with UHV and ultra clean compatible versions available. When coupled with New Focus' range of stable translation stages and mounts it is well suited for many application requiring remote and automated beam alignment, sample-stage positioning, nudging or ultracompact layout designs. The *Picomotor*™ can be integrated into an automated system with ease through direct computer control, a joystick controller and multichannel keypad controller. If you require precision, stability and performance that is second to none, consider New Focus. They are *Simply Better*.

Contact Coherent Scientific for further information.
116 Sir Donald Bradman Drive
Hilton SA 5033
Ph: (08) 8150 5200
Fax: (08) 8352 2020
sales@coherent.com.au
www.coherent.com.au

PM panda fibre optical attenuator

Polarization maintaining fixed attenuator is based on micro-optics technology; it can achieve very high attenuation precision. The device is pigtailed†and it can supply with 250um panda fiber or with connectors, 20dB Min extinction ratio and 55dB min return loss. The PM fiber attenuator is widely used in optical communication systems, lab research, sensors and receivers. The device can supply with customer specified attenuation values.
Email: *sales@afwtechnology.com.au*
Tel: 03 9702 4402

Versatile Vibration Isolation Workstation

Warsash Scientific, introduces the MK26, a versatile new Vibration Isolation Workstation designed for ultra-low natural frequency applications from Kinetic Systems Inc. The workstation utilizes Minus KÆ patented negative-stiffness vibration isolators to provide a compact, passive workstation with ultra-low natural frequencies, higher internal structural frequencies, and excellent vertical and horizontal isolation efficiencies.

The Minus KÆ vertical isolator uses a stiff spring and a negative-stiffness mechanism to achieve a low net vertical stiffness without affecting the static load supporting capability. Horizontal isolation is provided by beam columns connected in series with the vertical-motion isolator. Adjusted to a Ω Hz natural frequency, the workstation achieves 93% isolation efficiency at 2 Hz, 99% at 5 Hz, and 99.7% at 10 Hz.

Produced in collaboration with Minus K Technology, Inc., the Kinetic Systems MK26 Vibration Isolation Workstation can be configured for a wide variety of applications where disturbances due to external vibrations can adversely affect the operation of sensitive equipment. Customization options for specific applications include guard rails, padded armrests, overhead equipment shelves, monitor stands, non-isolated shelves for supporting equipment off the tabletop, oversized keyboard shelves, retractable casters, Faraday Cages to protect sensitive operations from electromagnetic interference, tabletop enclosures to protect against harsh manufacturing environments, and electrical accessories such as outlet strips for lighting.

The MK26 is available with up to 295kg gross load capacity. It is Class 100 cleanroom compatible, with Class 10 available as an option. Tabletops can be ordered in two sizes (30" x 36" and 36" x 48") and either in lightweight "honeycomb" or composite construction.

Applications for the MK26 Vibration Isolation Workstation include analytical balances, cell injection, confocal microscopes, patch clamping, optical microscopes, wafer probing, sensor calibration, and atomic force microscopes in fields such as semiconductor processing, telecommunications, aerospace engineering, and medical research.

Further information from WARSASH Scientific Pty Ltd at (02) 9319 0122 or *sales @warsash.com.au*

New Oxxius lasers

Oxxius has developed two advanced product platforms aiming at offering acost- and performance-optimised solution to the growing market forvisible and near-UV sources.One platform relies on a diode-pumped solid-state laser (DPSS)architecture and is used in the SLIM product line. The other, the OxxiusViolet product family, is based on GaN laser diodes.The SLIM product line is a family of continuous-waveDPSS lasers withthe smallest footprint on the market. It leverages a unique technology,the Alignment-free Monolithic Resonator (AMR). AMR-based lasersinherently offer a consistently low noise and a single-frequencyemission. Furthermore, this monolithic solution greatly simplifies thelaser assembly process and offers long-term stability. The SLIM productline includes the SLIM-473, a blue (473mm) CW laser module as well asthe SLIM-532 and SLIM-561.The Oxxius Violet product line is a best-in-class family ofviolet-to-near-UV laser modules based on GaN semiconductor diodes. It isavailable today at wavelengths of 405, 375 and 445 nm.Both product platforms offer common advantages to academics and OEMsalike - compactness, low power and voltage requirements, advancedelectronics and thermal design, high spectral and spatial beam qualityand long-term stability and no maintenance.For more information on these exciting products please contact one ofthe experienced sales staff at Photon Engineering on (08) 8232 3444 or

sales@photonengineering.com.au

www.photonengineering.com.au

Newport Release 1935-C Optical Meters.

Newport expanded its family of power and energy meters with the launch of the 1935-C series of optical meters. This new product family is ideal for measuring optical power and energy from any type of laser, laser diode or broadband light source. Designed to be easy-to-use, the meters are well-suited to various research and development applications, as well as in QA testing, and manufacturing.

"Newport has supplied the industry's most innovative power and optical meters for over a decade, and the new 1935-C series builds on this excellence. We believe it will be another flagship instrument for the laser and photonic industry, thanks to its powerful combination of features, performance and versatility," says Ron Hartmayer, Newport's Director of Marketing for Photonics Instrumentation.

Key Features
- Optical power measurement in the 100fW to 10W range
- Up to 20 kHz of pulsed measurements
- Up to 250,000 data points of internal storage capability
- USB port access to expand internal memory
- Menu-driven interface with soft keys and help functions
- Large, full-color VGA display of instrument settings and measurement data
- Easy-to-change color settings that are compatible with various laser safety goggles

For more information please contact Neil McMahon NewSpec Pty. Ltd. Phone: (08) 8273 3040 Email: *sales@newspec.com.au* Web: www.newspec.com.au

Matisse™ CW Ring Lasers

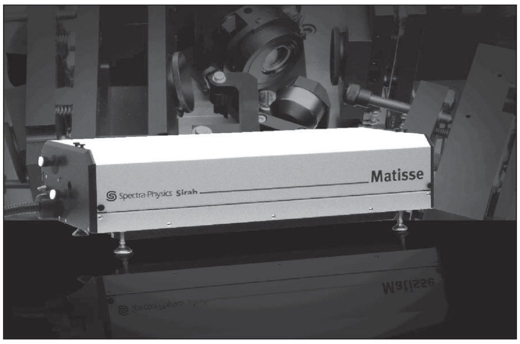
The Matisse™ is a unique source of broadly tunable, very narrow bandwidth radiation (<50kHz). It is†"pumped" by a Millennia™ series Green Diode Pumped Solid State laser, also from Spectra-Physics. The laser resonator cavity is designed as a ring structure, as opposed to the more typical standing wave linear cavities. It forces the light that is resonating in the cavity to go in one direction only, and by introducing various line narrowing elements, the laser can be made to run single frequency. This means that the laser is operating on a single longitudinal mode (SLM) with a very narrow spectral bandwidth.

The Matisse™ offers features and benefits emanating from significant progress of ring laser cavity designs that implement key electro-optical technologies. Like other products from Spectra Physics, the Matisse™ also utilizes cutting edge digital electronics and control. Furthermore, composite materials are used to dampen the effects of performance reducing vibrations. Other major advantages offered by this new laser are the electro-optic modulator that stabilizes the cavity length, and the very stable, temperature stabilized wavelength reference cavity.

The Matisse™ is ideal for scientific and engineering research applications such as high resolution spectroscopy, atomic time standards, optical computers, trapping of cold atoms … molecules and study of Bose- Einstein Condensates.

Key Features
- Ultra-narrow spectral bandwidth in the 10's of kHz.
- Low noise CW power output and low sensitivity to micro phonics.
- Highly accurate wavelength scanning.
- Ease of use with accessible opening design.
- Available in both Ti:Sapphire and dye versions

For more information please contact Graeme Jones NewSpec Pty. Ltd. Phone: (08) 8273 3040
Email: *sales@newspec.com.au* Web: www.newspec.com.au



Gentec EO P-LINK : PC-based Power Monitor

A new OEM PC-based power monitor that is compact, economical, and with a free software! Gentec-EO now offers you the P-LINK, an economical single channel power monitor with very compact size and advanced features that make it the perfect candidate for integration in machines. You can then control it with our PC-LINK software or with PC serial commands. You can even connect many P-LINK units to a single computer, which makes it a device of choice for the simultaneous monitoring of many laser power meter.

Installation and startup could not be easier. Just plug the detector into P-LINK. Then plug P-LINK into your PC, click on the PC-LINK icon and you are ready to go. Just as with the SOLO PE, the P-LINK will recognize your Gentec-EO power head as soon as you plug it in. Not only does the USB connection provide the communication link but it also supplies the power for P-LINK. The only extra step for the RS-232 model is connecting the power supply.

The P-LINK retains most of the SOLO features. That includes the anticipation circuitry for fast response. You also get data sampling, statistics, and analysis functions. Use the defaults or select your own sampling rate, sample period or total duration to do the statistics. You also have access to correction factors (one multiplier and one offset) for enhanced measurement flexibility.

Features:
- PC Serial commands
- Power/Photo Detectors
- Extremely compact
- Now with expandable windows, just like PC-SOLO
- Easy installation
- Economical
- Optional USB or RS-232 interfaces
- OEM PC-based Power Monitor, including free software upgrade
- Data sampling, statistics, and analysis functions
- Includes anticipation circuitry for fast response

For further details please contact Lastek at
sales@lastek.com.au <mailto:sales@lastek.com.au>
Lastek Pty Ltd
Phone: (08) 8443 8668
Toll Free: 1800 882 215 (NZ: 0800 441 005)
www.lastek.com.au

Oriel IS Series Minispectrometers

The Oriel IS-Series of Minispectrometers offer significant advantages over traditional minispectrometers. Oriel offer models to cover various spectral ranges, in both fiber-coupled and free-space configurations, for high resolution and moderate resolution needs. Instruments are also available to cover NIR spectral ranges upon special request.

The Oriel IS-Series of Minispectrometers offer significant advantages over traditional minispectrometers. We took our 30+ years of designing and manufacturing spectroscopic instruments, combined with the feedback from you, our customers, and designed a family of instruments that truly addresses the needs of both the Researcher, and the Systems Integrator. We offer models to cover various spectral ranges, in both fiber-coupled and free-space configurations, for high resolution and moderate resolution needs. For NIR spectral ranges, contact a Sales Engineer

Features:

- NMOS Photodiode detector for superior UV sensitivity
- Various spectral ranges from 190 to 1000 nm
- High resolution models: 0.45 nm
- USB 2.0 communication to PC
- Convenient fiber based systems and versatile free-space systems

For more information contact Neil McMahon at *neil.mcmahon@newspec.com.au*

SpitfireÆ Pro XP Ultrafast Ti:Sapphire Amplifier

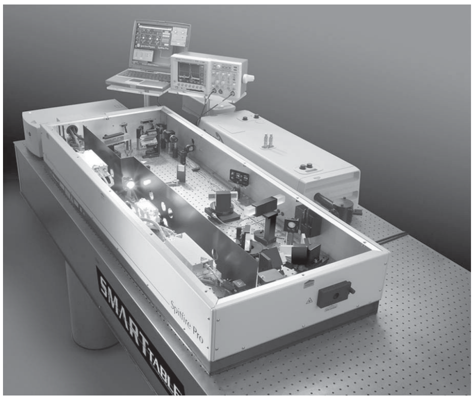
The Spitfire[Æ] Pro XP multi-kilohertz Ti:Sapphire regenerative amplifier extends the capabilities of the Tsunami[Æ] and Mai Tai[Æ] mode-locked Ti:Sapphire oscillators. It has become the world's most popular ultrafast amplifier system by combining cutting edge performance and high reliability with industry leading technical support.

The Spitfire Pro XP is the first commercial ultrafast amplifier to deliver both high power (up to 5 Watts) and superior beam quality (M^2 <1.5), ideal to pump multiple OPAs. Its new all digital and computer controlled timing system provides ease of use and enhanced performance. To cover all your experimental needs, the Spitfire Pro XP tunability can be extended by harmonic generation (SHG, THG, FHG) and OPA pumping (from <189 nm to >20 microns).

Features:

- Pulse width as short as <35 fs
- Output energies up to 5 mJ
- Near Gaussian, near diffraction limited output beam
- Diode-pumped technology offers exceptional pulse-to-pulse stability
- Greatest flexibility in Nd:YLF pump lasers
- Wavelength extension through SHG, THG, FHG, OPA
- Complete package (autocorrelator and spectrometer) for system diagnostics

For more information please contact Graeme Jones
NewSpec Pty. Ltd.
Phone: (08) 8273 3040
Email: *sales@newspec.com.au*
Web: www.newspec.com.au



Piezesystem Jena PXY 15 CDT

Ultra fast piezo scanner with parallel kinematics piezosystem jena has implemented the advantages of parallel kinematics during the development of a high-performance piezo scanner. All actuators affect the same moving plate - unlike serial kinematicsystems, thus the resonant frequency and the dynamic behavior are improved. The actuators for both moving axes have one common fixed point therebyavoiding a serious disadvantage of serial kinematics in which the second axis is moved by the first.

The PXY 15 CDT elements were developed especially for optical scanning applications. These systems are optimized for a very high resonant frequency and an excellent high stiffness in all axes. Originally the stage was designed especially for mounting optical lenses, now different versions for fast and precise movement of mechanical parts are available. The internal pre-load and the design without mechanical transmission make this actuator well suited for high frequency applications up to the kilohertz range.

Features:

- motion in x- and y- axes up to 20µm
- high resonant frequency
- high stiffness
- minimum z-motion
- free central hole up to inner diameter of up to 66 mm

Applications:

- scanning systema with highest z-axis - stiffness and resonant
- frequency
- ray- / beam deflection
- surface scanning

For further details please contact Lastek at
sales@lastek.com.au <mailto:sales@lastek.com.au>
Lastek Pty Ltd
Phone: (08) 8443 8668
Toll Free: 1800 882 215 (NZ: 0800 441 005)
www.lastek.com.au

APBP2007

3rd Asian and Pacific rim symposium on BioPhotonics
&
Biophotonics Downunder II

Conference Co-Chairs
Prof. Min Gu, Dr. Daniel Day
Conference Secretariat
Katie Cage, kcage@swin.edu.au

July 9 - 11, 2007 Cairns Australia
Shangri-La Hotel

Topics
- Photo-therapy
- Laser tissue interactions
- Multi-photon microscopy
- Laser tweezers and trapping
- Digital holographic microscopy
- Spectroscopy for biomedical applications
- Photo-acoustic and hybrid imaging systems
- Microfluidic devices for biomedical analysis
- Gated and diffuse optical imaging techniques
- Optical coherence tomography and clinical applications
- Novel technologies for medical diagnostics and treatment

SWINBURNE
CENTRE FOR MICRO-PHOTONICS

OPTICS SHOP

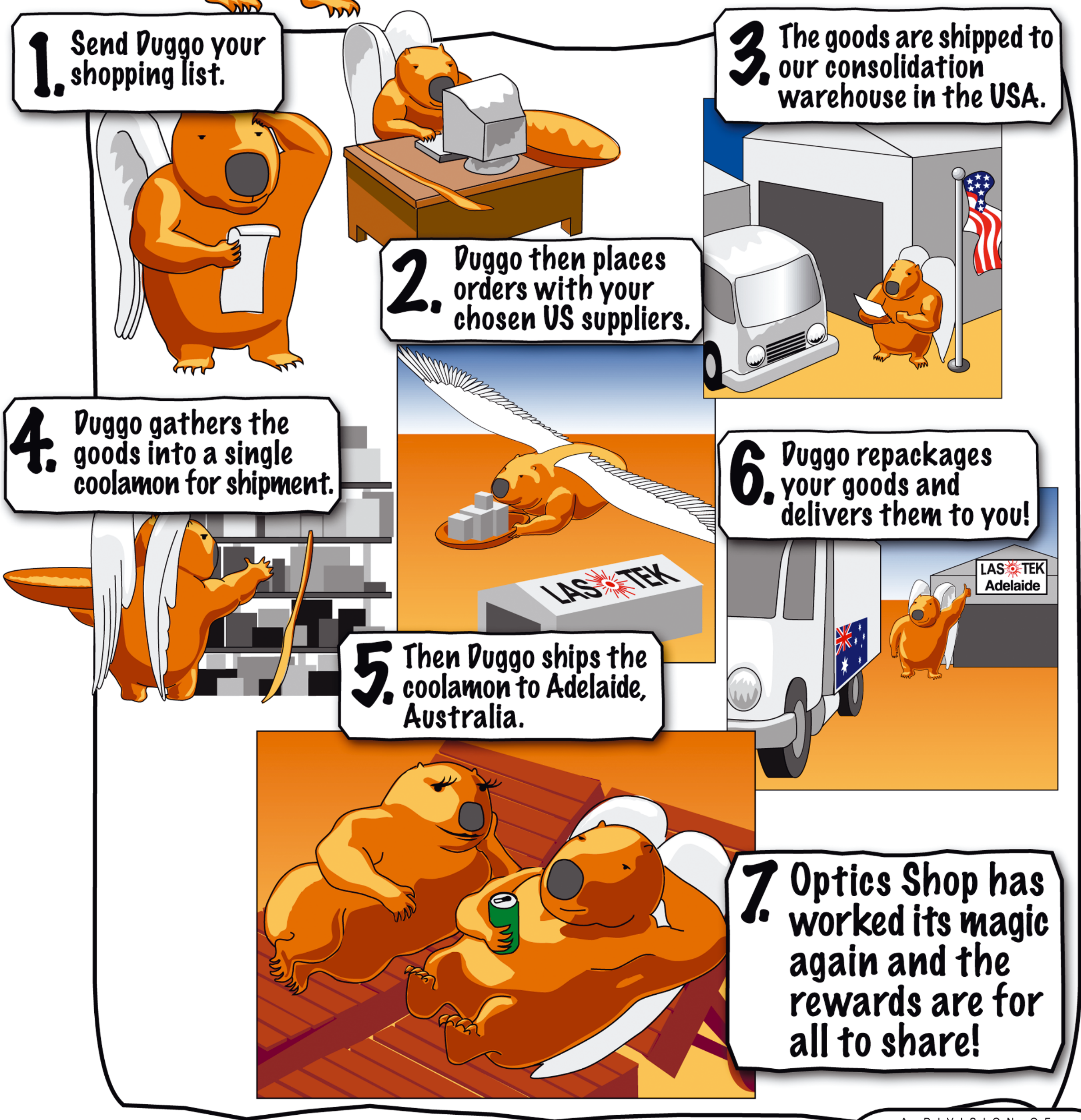
The OpticsShop Shipping Process

Meet Doug, OpticShop's high flying, goods routing wombat - Duggo to his mates!

Duggo will demonstrate how he can deliver small items from America, cheaper.

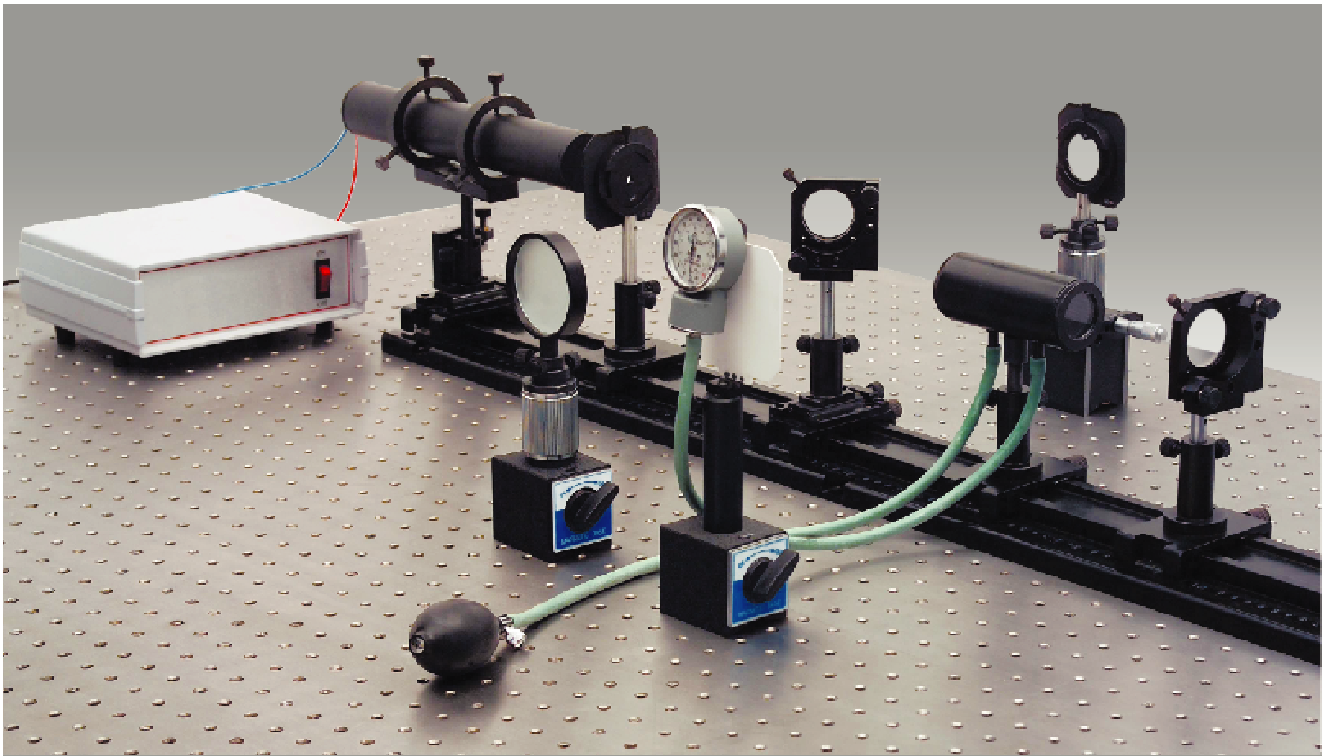
Duggo can even deliver books from Amazon to Australia cheaper than Amazon can.

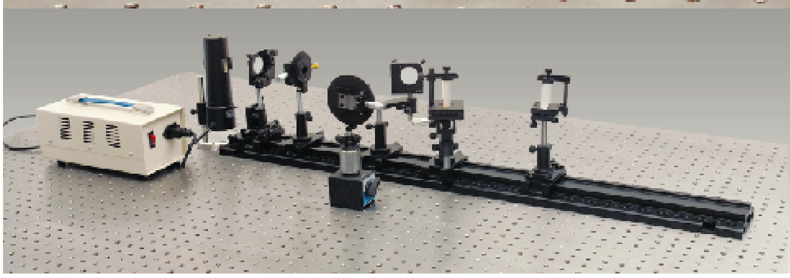
Who can? Ya mate Duggo can!

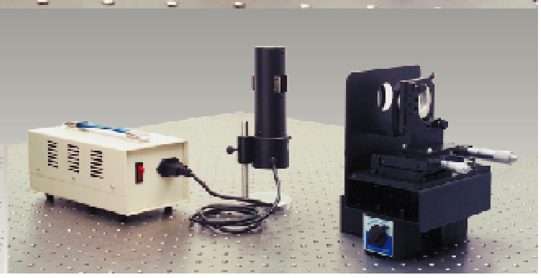


Lambda Scientific is a global supplier of scientific instruments, specializing in developing and manufacturing various physics education equipment/kits, spectroscopic instruments, opto-mechanic parts and laboratory lamps

LEOK-3 Optics Experiment Kit







LEOK-3 allows users to construct many optics experiments required in general physics education. It provides a complete set of optical, mechanical parts and light sources and can construct **26** experiments in the following categories.

- Lens measurement
- Optical instruments
- Interference phenomena
- Diffraction phenomena
- Polarization analysis
- Fourier optics and holography

www.lambdasci.com

Lambda Scientific Pty Ltd
2/147, Buxton Street, North Adelaide SA 5006 Australia
Phone: +61 8 8267 2686
Fax: +61 8 8267 2689
E-mail: sales@lambdasci.com

Laser Accessories

Vibration Isolation Tables, Platforms & Workstations

Kinetic Systems offers a comprehensive range of passive or active vibration isolated optical tables, workstations & platforms offering:

- Large Range of Sizes & Performance Levels
- SPILLPRUF Spill Management System
- Variety of TableTop Materials
- Optional Accessories Including Casters, Guard Rails, Armrest, Faraday Cages, Enclosures, Additional Shelves & Many More
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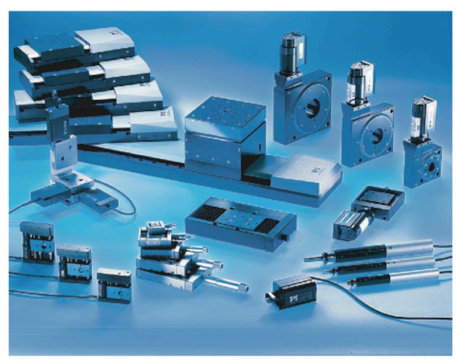

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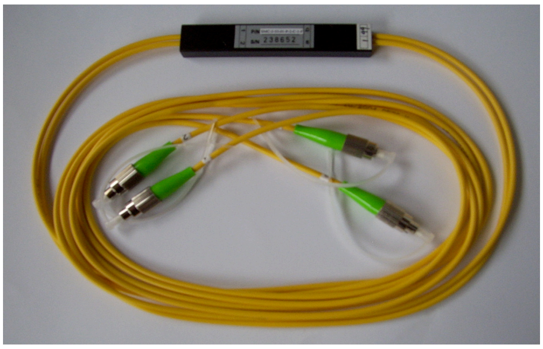

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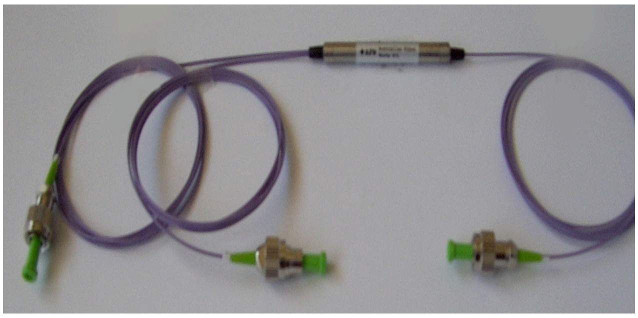

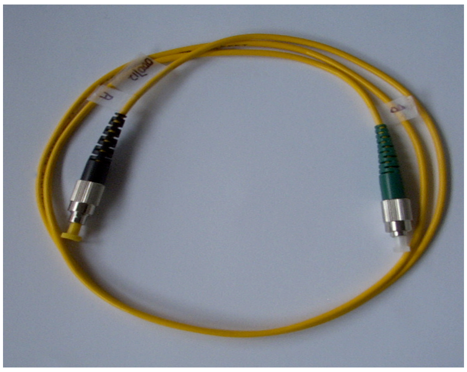

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X-ray optics for the future: high-accuracy measurements of x-ray mass attenuation coefficients

Martin D. de Jonge, Chanh Q. Tran, Christopher T. Chantler, Zwi Barnea
School of Physics, University of Melbourne, Victoria 3010, Australia

We have applied the x-ray extended-range technique (XERT) to measure mass attenuation coefficients almost two orders of magnitude more accurately than any previously reported in the literature. How, and why? New fields of physics are uncovered by such accuracy, as with, for example, the speed of light. Of course, this in part depends on the development of highly-accurate calibration procedures for x-ray systems, which in turn has additional consequences for future applications.

In this article we describe the application of the XERT to the investigation of systematic effects due to harmonic energy components in the x-ray beam, scattering and fluorescence from the absorbing sample, the bandwidth of the x-ray beam, and thickness variations across the absorber. The measurements are used for comparison with different calculations of mass attenuation coefficients, and to identify particular regions where these calculations fail. Absolutely-scaled data with robust error estimates in the region of the x-ray absorption fine structure (XAFS) can be used to improve the accuracy of XAFS analysis and can provide a rigourous test of the absolute scale of XAFS modelling.

INTRODUCTION

The accuracy of x-ray optical constants can significantly affect the optimisation of an experimental arrangement and the interpretation of experimental results. For example, x-ray atomic form factors and mass attenuation coefficients can affect the interpretation of tomographic and crystallographic experiments, and can influence the design of x-ray refractive lenses and zone-plates. Despite significant differences between various tabulations of mass attenuation coefficients, these tabulations are often used with little discrimination.

Figure 1 presents the mass attenuation coefficients of molybdenum appearing in the FFAST [1–3] and XCOM [4, 5] tabulations as raw values (top) and as a difference from the FFAST tabulated values (bottom). Significant differences between the calculated values are observed across a wide range of energies both above and below the absorption edge of molybdenum at about 20 keV, and exceed 15% at some energies. Similar discrepancies between calculated values are present in all tabulations, for all elements, and across all x-ray energies.

The results of measurements of the mass attenuation coefficients of molybdenum compiled by Hubbell *et al.* [6, 7] are plotted on Fig. 1. These experimental results generally claim uncertainties of between 1% and 2% belied by a spread of up to 20%. These measurements are unable to resolve differences between FFAST and XCOM tabulations or other theoretical works. Discrepancies between the results of independent investigations indicate that there are significant and undiagnosed systematic errors which have affected the accuracy of the measurements [8, 9]. This article reviews key aspects of our methods for investigating these sources of systematic error and their effects on the measured mass attenuation coefficients.

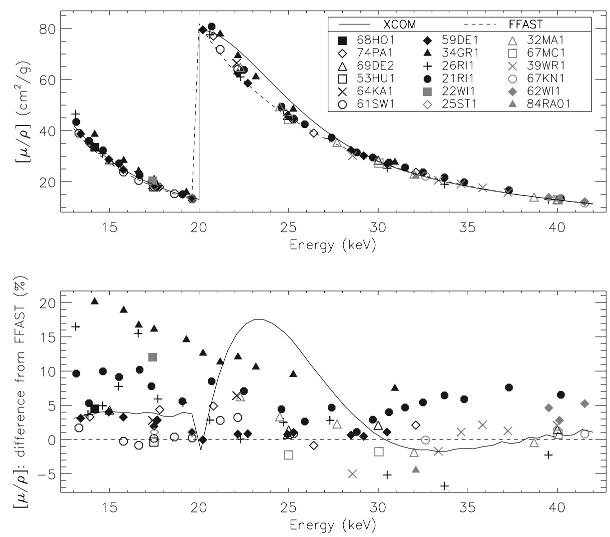

FIG. 1: Top: The mass attenuation coefficient for molybdenum as given in the FFAST [1–3] and XCOM tabulations [4, 5], and as reported by a variety of previous experimental investigations (experimenter code referred to in the key is as per Hubbell *et al.* [6, 7]). Bottom: Discrepancies between theoretical predictions and experimental measurements presented as a percentage difference from the FFAST tabulation. The difference between the FFAST and XCOM tabulations is greater than about 4% over most of the energy range shown here, but rises to over 15% over several keV above the absorption edge. Differences of 10%–20% between measured values whose typical claimed uncertainties are about 2% indicate the presence of unrecognized systematic errors affecting these measurements.

METHODOLOGY

The XERT probes and hence calibrates several dimensions of the measurement parameter-space to determine the influence of a range of systematic effects on the mea-

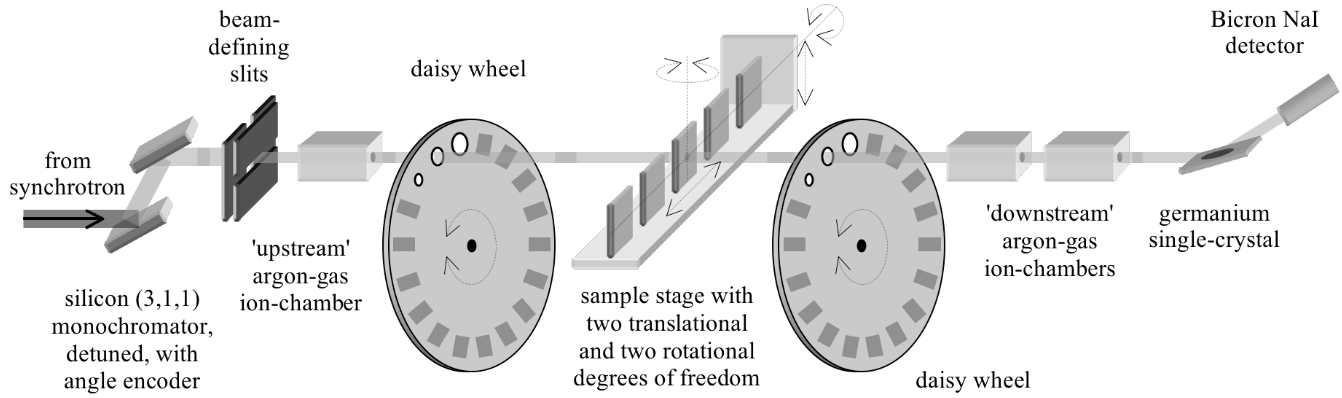

FIG. 2: Schematic of the experimental components used to employ the XERT.

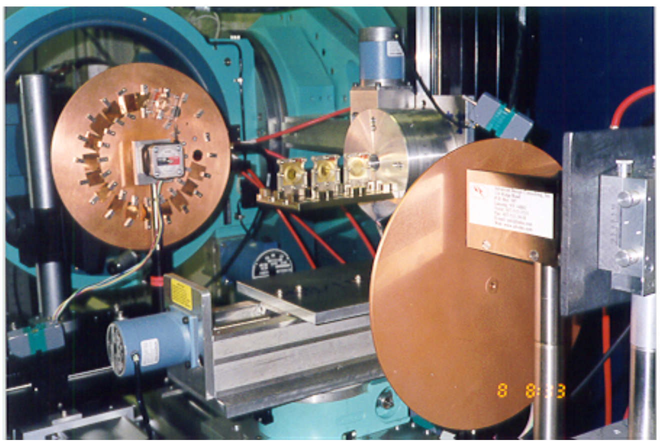

FIG. 3: Typical arrangement of the experimental components used to employ the XERT.

sured values [10]. We make measurements under optimum conditions and continue these measurements well beyond the optimum range. Critical examination of the limitations near extremes is used to estimate the implications, if any, on measurements made under optimal conditions. This article describes our treatment of systematic errors arising from the presence of harmonic energy components, the effects of secondary radiation (scattering and fluorescence), the influence of the finite x-ray energy bandwidth, and from absorber thickness variations. These methods have been applied to measurements of the mass attenuation coefficients of copper [11], silicon [12], silver [13], and molybdenum [14]. Explicit tests for the effects of a wide range of systematic errors have enabled us to rigorously justify experimental accuracies of between 0.02%–0.7%.

Figure 2 presents a schematic of the experimental setup that we have used to measure mass attenuation coefficients. The exact details of the experimental arrangement vary depending upon the synchrotron beam-line used. We have used bending magnet, undulator, and elliptical multipole wiggler sources to produce a spectrum of high-brilliance x-rays, and find that all such sources are very amenable to our techniques and approach. That high accuracy can arise under such varied conditions might even seem surprising, in that synchrotron sources are very often far from stable by laser-optical standards.

The x-ray beam is monochromated by double reflection from a monochromator, usually silicon, and preferably from planes with a 'forbidden' second-order reflection [such as (111) or (311)]. The monochromator is usually detuned to reduce the passage of higher-order harmonics into the beam [15, 16].

Counting statistics have often limited measurement precision in a number of reported measurements of mass attenuation coefficients [17–20]. We have used high-brilliance synchrotron sources to obtain measurements with high statistical precision as a minimal pre-requisite for accuracy. The improved statistical precision of our measurements has made it possible to detect a range of systematic effects which would otherwise not be discernible from the data.

The x-ray beam is collimated to a cross-section of approximately 1×1 mm^2 by the use of two orthogonal slits. An 'upstream' ion chamber is used to monitor the intensity of the incident beam, and a 'downstream' ion chamber to record the intensities of the attenuated and unattenuated beams. We use matched ion chambers, and optimise for strong positive correlations between the counts recorded in the upstream and downstream ion chambers [21, 22]. Accordingly, gas is flowed through the ion chambers in a serial configuration. We have generally recorded measurements with correlation $R \geq 0.99$, which enables us to determine the ratio of the measured intensities to high precision. This precision enables us to detect the effects of systematic errors on the measurement with high sensitivity.

A number of specimens of widely differing attenuation $(0.5 \leq \left[\frac{\mu}{\rho}\right][\rho t] \leq 5)$ are used to measure the x-ray attenuation at each energy. The samples are mounted on the sample stage, shown in Fig. 2, which is located mid-way between the upstream and the downstream ion chambers. The stage can be rotated about two axes and translated in two directions orthogonal to the beam. The samples are placed and replaced in the path of the beam to high precision by the use of a computer-controlled motorized driving system. By contrast, previous methods and the literature standards almost always use a single sample thickness, and hence spend much discussion upon what the 'best thickness' should be. Our results prove that no single thickness is adequate, and that the notionally optimum region is quite different and broader than thought.

Daisy-wheels [23] are located between the sample stage and the ion chambers. These daisy-wheels have on their perimeters a series of apertures which are used to admit different amounts of secondary (fluorescent and scattered) photons into the ion chambers. In addition to these apertures, a large number of attenuating foils are mounted on the perimeter of the daisy-wheels and these can, like the apertures, be placed in the path of the beam by suitable rotation of the daisy-wheel. The thicknesses of the daisy-wheel foils are chosen to span an extremely large range of x-ray attenuations, typically with $0.01 \leq \left[\frac{\mu}{\rho}\right][\rho \mathrm{t}] \leq 50$ at the nominal x-ray energy.

HARMONIC COMPONENTS

When attenuation measurements are made using a monochromatic x-ray beam, the logarithm of the intensity plotted as a function of the absorber thickness t falls on a straight line whose slope is the product of the mass attenuation coefficient $\left[\frac{\mu}{\rho}\right]$ and the density ρ of the foil material, as described by the Beer-Lambert relation

$$\ln\left(\frac{I}{I_0}\right) = -\left[\frac{\mu}{\rho}\right]\rho\, t, \tag{1}$$

where I and I_0 are the attenuated and unattenuated intensities respectively. The product $\left[\frac{\mu}{\rho}\right]\rho$ is sometimes referred to as the linear absorption coefficient μ, but we use the alternate notation for consistency.

In practice, $\ln(I/I_0)$ can be non-linear with thickness due to the presence of other spectral components in the beam. In particular, harmonic multiples of the fundamental x-ray energy may be present in the beam, especially when their intensities in the source spectrum are significant. While detuning of the monochromator crystal may suppress the propagation of these harmonic components in the beam, the residual effect on the measured attenuation can be large.

The relative efficiency of detection of the fundamental and of the harmonic x-rays influences the effect of any harmonic components on an attenuation experiment. In particular, the ion-chamber detectors used in our work exhibit a rapid decrease in detection efficiency with in-

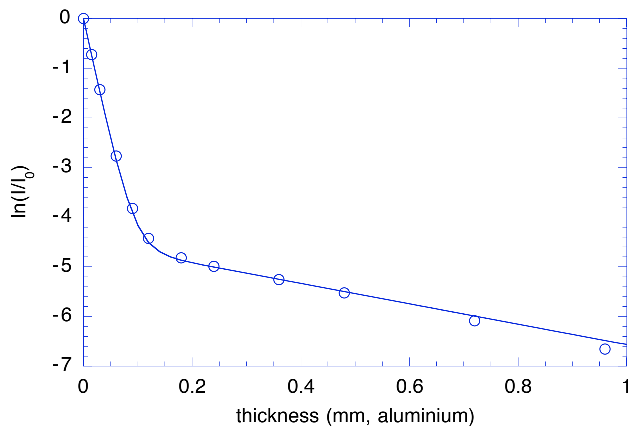

FIG. 4: The attenuation $\ln(I/I_0)$ as a function of the thickness of aluminium absorber in the x-ray beam with a silicon monochromator set to 5 keV. $\circ$ - experimental values; solid line - curve of best fit corresponding to an admixture of $(1.09 \pm 0.02)\%$ third-order harmonic (15 keV) following Eq. (2).

creasing x-ray energy, suppressing the harmonic components. However, the *effective* harmonic content, i.e., as perceived by the detector, can still be significant, as was the case in our measurement of the mass attenuation coefficient of silicon [12], which we describe here.

For a fraction x of harmonic x-rays (with attenuation coefficient $\left[\frac{\mu}{\rho}\right]_h$) in the incident monochromatised beam (with $\left[\frac{\mu}{\rho}\right]_f$ the attenuation coefficient for the fundamental energy), the measured attenuation of the x-ray beam $\left[\frac{\mu}{\rho}\right]_{meas}\rho\, t$ will be [23]

$$\begin{aligned} &-\left[\frac{\mu}{\rho}\right]_{meas}\rho\, t = \ln\left(\frac{I}{I_0}\right)_{meas} \\ &= \ln\left[(1-x)\exp\left\{-\left[\frac{\mu}{\rho}\right]_f\rho\, t\right\} + x\exp\left\{-\left[\frac{\mu}{\rho}\right]_h\rho\, t\right\}\right]. \end{aligned} \tag{2}$$

Figure 4 shows the measured attenuation of eleven sets of aluminium foils (with thicknesses between 15 μm and 1 mm) in the path of an x-ray beam monochromated by a detuned, double-reflection silicon (111) channel-cut monochromator set to select 5 keV x-rays. These foils were placed in the beam by suitable rotation of the daisy wheel. This technique is accurate, reproducible and rapid. This work was performed at the bending magnet beamline 20B of the Photon Factory synchrotron at Tsukuba.

The experimental values follow a straight line until the thickness of aluminium increases to such an extent that the detected radiation consists overwhelmingly of the more energetic 15 keV third-order harmonic. When this occurs, one observes an inflexion with the gradient approaching that of $\left[\frac{\mu}{\rho}\right]\rho$ of aluminium at the energy of the third-order harmonic.

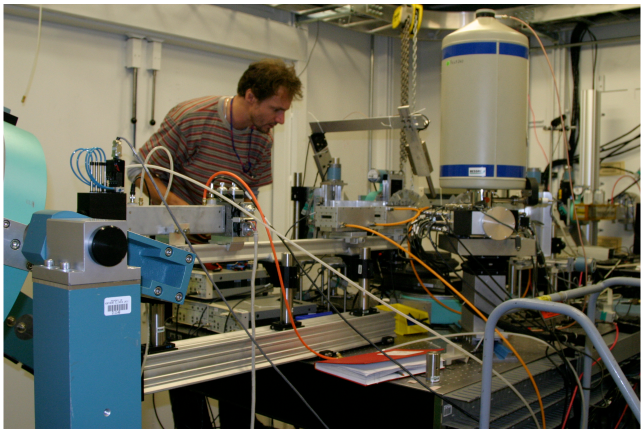

FIG. 5: Martin reconsidering the alignment of the experimental components for the detection of scattering.

This inflexion in the plot provides clear evidence for the presence of a third-order harmonic [the (222) second order reflection for silicon is 'forbidden']. The solid curve in Fig. 4 is the calculated thickness dependence of the attenuation of aluminium for 5 keV x-rays with an admixture of $(1.09 \pm 0.02)\%$ of the 15 keV third-order harmonic, as can be confirmed by extrapolating the second 'linear' portion of the graph back to zero thickness.

Our measurements of the effect of the beam harmonic component have enabled us to determine the mass attenuation coefficient of silicon at these low energies to accuracies of 0.3%–0.5%.

THE FULL-FOIL MAPPING TECHNIQUE

Recent reports [17–19, 24–27] have found that a dominant limiting source of error in the measurement of mass attenuation coefficients at between 0.5%–2% is the accurate determination of the thickness of the absorber along the path traversed by the x-ray beam. We have developed a full-foil mapping technique for determining the mass attenuation coefficient on an absolute scale which overcomes previous limitations due to uncertainties in the thickness of the absorber.

Traditionally the local value of the integrated column density has been determined as the product of the density and the thickness. The local thickness was determined by a variety of techniques using micrometry [11, 12, 20, 27, 28], profilometry [11], optical microscopy [29], step-profilometry [30], and x-ray scanning techniques [11, 12, 20]. Measurements of sample thickness have the advantage that they probe the variation of the thickness across the surface of the foil. However, these techniques have a range of fundamental problems limiting precision and accuracy which are difficult to overcome [11, 12, 31].

More recent measurements have used the averaged thickness of the absorber, which we term the integrated column density, for the determination of the mass attenuation coefficient [11, 12, 17–19, 24, 26, 32–34]. However, these measurements have generally been limited to accuracies of 0.5%–2% due to variation in the thickness, which has limited the determination of the local integrated column density of the absorbing specimen along the column traversed by the beam.

The mass attenuation coefficient of a foil absorber can be determined by measuring the attenuation at (x, y) locations to determine an *attenuation profile* $-\ln\left(\frac{I}{I_0}\right)_{xy}$ of the absorber. The mass attenuation coefficient can then be determined from the average of the measured attenuation profile since, for a homogenous sample with fixed $\left[\frac{\mu}{\rho}\right]$ [35],

$$\overline{-\ln\left(\frac{I}{I_0}\right)_{xy}} = \overline{\left[\frac{\mu}{\rho}\right][\rho t]_{xy}} = \overline{\left[\frac{\mu}{\rho}\right]}\,\overline{[\rho t]_{xy}} = \left[\frac{\mu}{\rho}\right]\frac{m}{A}, \qquad (3)$$

where the mass m of a given area A of the foil is used to determine the average integrated column density $\overline{[\rho t]}$. The mass and area of the foil can be measured to high accuracy using well-established techniques, for example by using an optical comparator to determine area and an accurate microgram balance to measure mass. In sharp contrast to the previously mentioned techniques, this technique can be used to determine the mass attenuation coefficient to high accuracy without directly determining the local integrated column density at any point of the absorber.

Figure 6 shows the attenuation profile of a nominally 254-μm-thick molybdenum foil. This attenuation profile has been determined from the attenuation measurements of the sample mounted in a plastic holder. To determine the attenuation profile of the absorbing sample alone we have subtracted the small fitted holder component from the measured attenuation profile.

Using this technique we have recently determined the mass attenuation coefficients of molybdenum to an accuracy of 0.028% [35] and of silver to accuracies in the range 0.27%–0.7% [31]. Measurements of the attenuation profile of the silver foils at different energies have confirmed the reproducibility of the measurement at this high accuracy.

INFORMING THEORIES OF PHOTOABSORPTION

We have measured the mass attenuation coefficients of copper [11], silicon [12], silver [13], and molybdenum [14] using various synchrotron sources. Following the principles of the XERT, measurements were made over an extended range of every dimension of the measurement parameter-space, and were investigated for evidence of

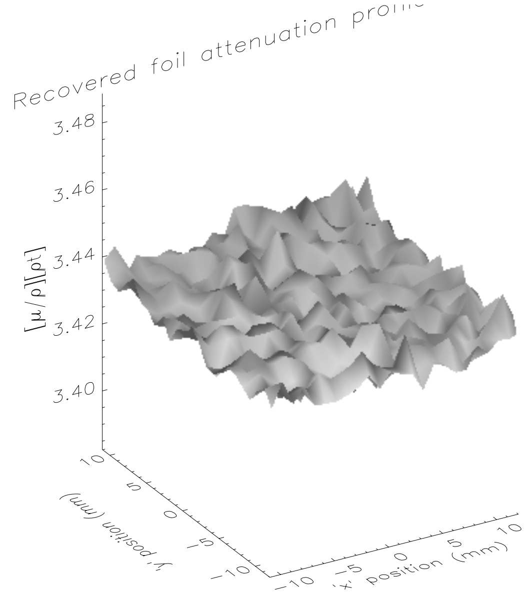

FIG. 6: Attenuation profile of a molybdenum foil. The attenuation profile was produced from an x-ray scan of the foil mounted in a plastic holder. The small holder contribution was fitted and subtracted from these measurements. The x-ray beam used to make the measurements was 1×1 mm^2 and measurements were taken at 1 mm intervals across the foil.

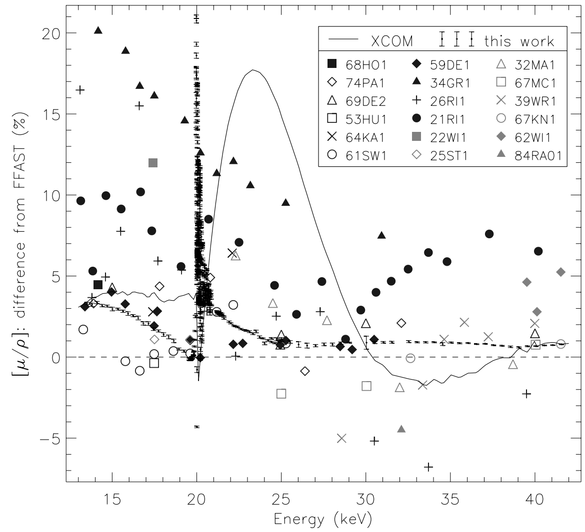

FIG. 7: Our measured values of the mass attenuation coefficients of molybdenum as a percentage difference from the tabulated FFAST values [1–3]. Measurement uncertainties of 0.02%–0.15% are indicated by the error bars. The spike in the difference of our values from the FFAST tabulated values occurring near the absorption edge is due to the XANES, which is not modelled by either tabulation. Also shown are the percentage differences between the tabulated XCOM [4, 5] values and the experimental values tabulated by Hubbell *et al.* [6, 7], compared with FFAST.

systematic errors. We have developed a technique to determine an accurate value of the mass attenuation coefficient from raster measurements made across the surface of an absorber. We have also detected and corrected effects resulting from a small fraction of harmonic energy components in the synchrotron beam, from fluorescent radiation produced in an absorbing specimen, and from the finite bandwidth of the x-ray beam. By applying these techniques we have improved measurement accuracies by up to two orders of magnitude.

This in turn allows us to investigate detailed physical processes including photoabsorption, fluorescence and scattering on an absolute footing, and hence permits investigation of the convergence of wavefunctions, transition matrices, computational approaches and such methods as X-ray Absorption Fine Structure. Some aspects of these applications are represented in the papers referred to herein.

Figure 7 presents our measured values for molybdenum compared with the FFAST tabulated values. Also shown are the XCOM calculated values and the experimental values tabulated in Hubbell *et al.* [6, 7], compared to the FFAST values. The trend of the percentage difference between our values and the FFAST tabulation is generally smooth to within the claimed measurement uncertainty, indicating that the uncertainties are appropriately estimated. By contrast, the point-to-point variations in the trend of the measurements tabulated by Hubbell *et al.* is typically no better than 1%–2% and is therefore the limiting possible precision of any of these measurements, with the accuracy necessarily being poorer. The large inconsistencies between the different sets of measurements prove the magnitude of present systematic errors in those data sets. We have explicitly investigated our measurements for the presence of such defects and have proven that each has a small or negligible remaining signature in our results.

The XCOM tabulated values exhibit a large oscillation with respect to the FFAST values over the energy range from 20 keV to 30 keV or 40 keV. Our measurements clearly prove that the XCOM tabulation is in error in this region. Oscillatory behavior in the calculated values has been observed elsewhere [1, 2] and may well be the result of an incompletely converged calculation. Above about 40 keV the XCOM values are in good agreement with our measurements.

The FFAST tabulation estimates uncertainties – arising from calculational convergence precision and the limitations of various approximations – at about 50% within $E_K \lesssim E \lesssim 1.001E_K$, 10%–20% within $1.001E_K \lesssim E \lesssim 1.1E_K$, 3% within $1.1E_K \lesssim E \lesssim 1.2E_K$, and 1% for $E \gtrsim 1.2E_K$ (E_K is the K-shell absorption-edge energy). These estimates are in accord with the differences of Fig. 7. The difference between our measurements and the FFAST tabulation is stable at about 0.5%–1% at energies above 25 keV. Below the absorption edge the measurements exhibit a more complex pattern of discrepancy, but fall between the XCOM and FFAST values.

The measured values are 1%–3% higher than the FFAST tabulated values within a range of about 5 keV above the absorption edge. Although this is within the FFAST uncertainty, a similar above-edge enhancement observed for copper [11] and silver [13] suggests that the FFAST values are systematically low in this region. The presence of this discrepancy in measurements of three elements indicates new physics in the above-edge energy region [13, 14, 36, 37]. Further experiments must determine whether this discrepancy is present for other elements and above other (e.g. *L*-shell) absorption edges. Such measurements will provide further clues which will inform future calculations of the mass attenuation coefficients.

XAFS structures are solved routinely and hundreds of publications appear per annum. Limitations in theoretical predictions and XAFS analytical frameworks lead to significant uncertainty in results, impairing structural predictions and preventing *ab initio* determination. Our accurate measurements and robust error estimates of the attenuation of molybdenum in the above-edge region have been used to improve the XAFS determinations by between 5% and 70% [38]. A deeper understanding of the interactions between x-rays and matter requires accurate measurements so that each contributing process may be compared with theoretical models. Relative measurements provide crucial information but absolute attenuation measurements provide additional demanding tests of theory and computation.

We acknowledge the assistance of the synchrotron staff at each of the beamline facilities involved in this work, being beamline 20B of the Photon Factory in Tsukuba, and beamlines 1-BM, 1-ID, and 12-BM of the APS. This work was supported by the Australian Synchrotron Research Program, which is funded by the Commonwealth of Australia under the Major National Research Facilities Program, and by a number of grants of the Australian Research Council. Use of the Advanced Photon Source was supported by the U.S. Department of Energy, Basic Energy Sciences, Office of Energy Research, under Contract No. W-31-109-Eng-38. MdJ acknowledges the Australian Optical Society and the SPIE for their support. This work is based upon MdJ's Ph.D. thesis[39].

THE AUTHORS

Martin de Jonge has recently completed a doctoral thesis, wherein he developed methods for making accurate measurements of the imaginary component of the atomic form-factor, Im(f). His measurements of molybdenum are the most accurate of their type, sufficient to

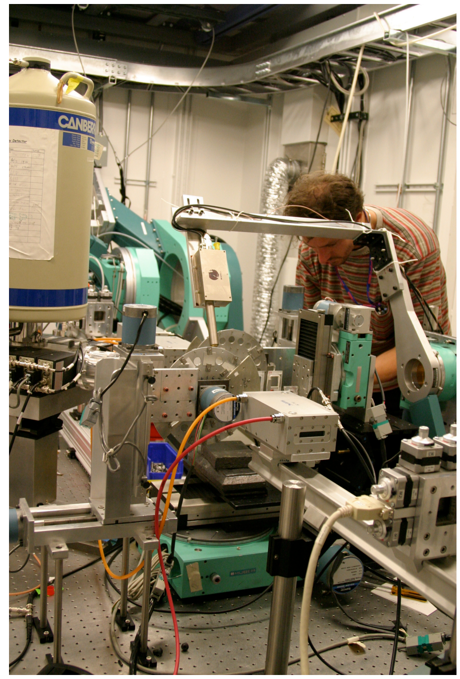

FIG. 8: Martin D. de Jonge in experimental mode, towards the end of a 40 hour shift!

FIG. 9: Chanh Q. Tran

challenge fundamental atomic theory. In 2002 he was awarded an AOS/OSA/SPIE travel prize, which enabled him to travel to the United States to present this work. He is currently enjoying a postdoctoral position at the intermediate-energy 1-4 keV beamline at the APS, developing techniques of x-ray coherent diffraction imaging and x-ray differential phase contrast microscopy. He has just been awarded the Chancellor's Prize for the best Science or Engineering doctoral thesis of the University of Melbourne.

Chanh Tran obtained his PhD in 2003 on the development of the X-ray Extended-Range Technique which enables precision calibration of synchrotron beam-line op-

FIG. 10: Christopher T. Chantler

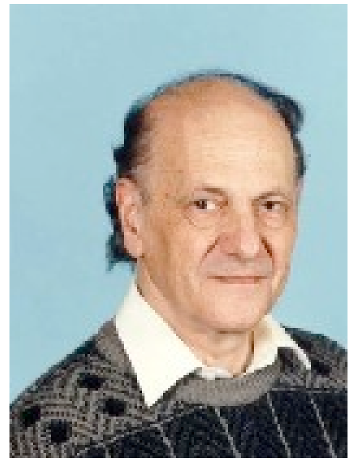

FIG. 11: Zwi Barnea

tics and sets the current standard for experimental determination of x-ray photon-atom interactions. Tran has already published 27 refereed papers including several in Phys. Rev. Letts., Phys. Rev. A and Phys. Letts. His research covers a broad range of activities including X-ray form factors, photoabsorption and scattering, x-ray optics, coherence, imaging and interference.

Chris Chantler is an Associate Professor and Reader at the School of Physics, University of Melbourne. He obtained his D. Phil. from Oxford in 1990, is a Councillor of the Australian Optical Society, and Associate Editor of AOS News; he was Scientific Program Chair of X-ray and Inner-Shell Processes 2005 and has co-chaired several AOS meetings. He has been a Member of the OSA and the American Institute of Physics since 1993; and a Member of the Australian Institute of Physics since 1992. Chantler has developed computation of X-ray atomic form factor theory, and his theory is the current NIST reference database on the subject. The Web database receives 10000 - 20000 hits per month as one of the major references for atomic form factors and attenuation coefficients. He has also produced the first absolute polarization studies performed on an EBIT, amongst the first investigations of Radiative Electron Capture to test QED, and worked on laser resonance spectroscopic tests of QED. He has built and directed the X-ray facility at the University of Melbourne over the last 12 years since returning to Australia from the USA. He has 83 papers submitted or published in refereed journals and over 195 papers and conference presentations, with over 118 citations on an individual publication.

Zwi Barnea is an Associate and Associate Professor Emeritus of the School of Physics, University of Melbourne. He obtained his doctorate in 1974. Barnea is among the few world leaders who have claimed and delivered 1% accuracy in form factor experiments. Barnea has over 67 publications in the field, cited up to 136 times. Barnea has developed new methods of x-ray intensity measurements and applied these to accurate measurements of structure factors, temperature factors, anharmonic thermal motion, bonding electron redistribution, anomalous dispersion effects, Bijvoet ratios, absolute intensity measurements of Bragg reflections and determination of extinction effects in real crystals. Barnea contributed to the design of "Big Diff", a multipurpose instrument on Australia's synchrotron beam-line in Tsukuba. This is a major success of Australian synchrotron development, and has been used by Barnea in various collaborations for measurements of X-ray absorption, phase retrieval, and diffuse scattering by metallic multilayers. Barnea developed methods for producing x-ray capillary optics for synchrotron beamlines and rotating anode laboratory generators where capillaries made it possible to study (30-micron) microcrystals of proteins in the laboratory.

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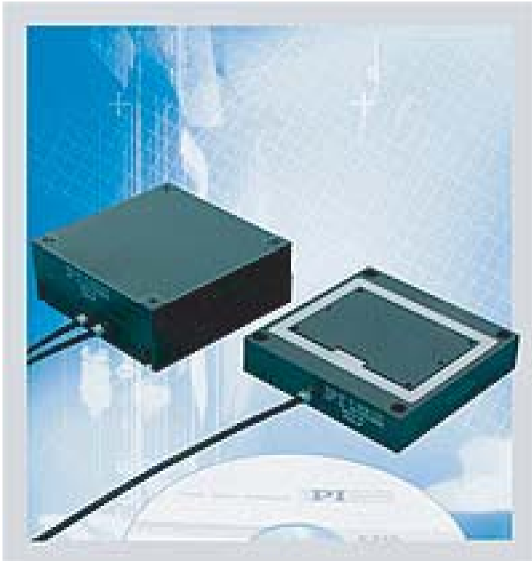

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NEWSLETTER

Commission Internationale d'Optique ● International Commission for Optics

Winter College looks at light in nature

This year's successful ICTP Winter College ran from 30 January to 10 February.

Eugene Arthurs, SPIE's executive director, presents the Educator Award diploma to Prof. Gallieno Denardo.

Sir Peter Knight, Imperial College, UK, delivers the opening lecture "Classical and quantum imaging".

Among the many activities that the International Centre for Theoretical Physics (ICTP) organizes every year, there is an important activity relating to optics and photonics – the Winter College. This is dedicated to subjects that are relevant to the training of young researchers from all over the world and, in particular, addresses researchers from less-favoured regions. This year the Winter College, which was held in Trieste, Italy, was dedicated to quantum and classical aspects of information optics, and it was successful for both the organizers and the participants.

The ICTP hosted the meeting and received 174 applications from the five continents. Among the delegates, some 40.5% received financial support for accommodation and, in the case of young researchers from developing regions, a higher rate was awarded for their attendance at the Winter College. The participants, from 46 countries, came to listen to 15 lecturers and to present their own research during the LAMP (laser, atomic and molecular physics) seminars. These are organized every year and give the many participants from all over the world the opportunity to talk about their current lines of research, motivations and projects. This year for the first time there was an interactive poster session.

The meeting was supported by the cosponsoring organizations: ICO (the International Commission for Optics), OSA (the Optical Society of America), SPIE (the International Society for Optical Engineering) and OWLS (the International Society on Optics Within Life Sciences). Its directors, Prof. M L Calvo (Complutense University of Madrid, Spain), Prof. P Knight (Imperial College, UK), Prof. P Tombesi (University of Camerino, Italy) and local organizer Prof. Gallieno Denardo (ICTP), selected outstanding international lecturers, who covered the whole range of this field in optics. The meeting was dedicated to reviewing the fundamental principles of light signals in nature, treated under a quantum scope as photons interaction and related devices that allow the observation and detection of photons in various physical states. In addition, the counterpart of the classical electromagnetic framework for light interaction was presented.

The aim of the meeting was to make postgraduate students aware of the most important research challenges in the field of optics and photonics today.

The following lecturers gave talks: T Alieva (Complutense University of Madrid, Spain), M Bastiaans (Eindhoven University of Technology, the Netherlands), V Buzek (Slovak Academy of Sciences, Slovakia), M L Calvo (Complutense University of Madrid, Spain), P Cheben (National Research Council of Canada), J I Cirac (Max Planck Institute for Quantum Optics, Garching, Germany), A Friberg (Royal Institute of Optics, Sweden), J C Gutierrez-Vega (Technological Institute of Monterrey, Mexico), P Knight (Imperial College, UK), P Kumar (Northwestern University, US), F De Martini (University La Sapienza, Italy), M Padgett (University of Glasgow, UK), J Rarity (Bristol University, UK), P Tombesi (University of Camerino, Italy) and L Yaroslavsky (Tel-Aviv University, Israel).

The above lecturers covered a broad range of subjects, including classical and quantum imaging, classical and quantum coherence, light's orbital angular momentum, optical beams, holographic and photonic devices, quantum repeaters and communication channels. The directors and lecturers recognized that the contributions made by the participants in the LAMP seminars and poster session lived up to the high international standard for which ICTP colleges are known.

It was pointed out that the interest and enthusiasm for advanced research in emerging areas such as optical computing, classical coherence, quantum information and quantum computing are not restricted to the industrialized countries. These activities contribute positively to reduce the scientific training gap between nations and ensure the future availability of infrastructures for future generations of researchers and local technology.

The following participants presented seminars on their current research activities: M Aqueel Ahmad (Imperial College, UK), N Arshed (Quaid-I-Azam University, Pakistan), I Ashraf Zaid (Quaid-I-Azam University, Pakistan), J E Barkai (Bar Ilan University, Israel), S V Boriskina (V Karazin National University, Ukraine), S L Daffer (Imperial College, UK), A S Desyatnikov (Australian National University, Australia), L Hernández-Pozos (Universidad Autónoma Metropolitana, Mexico), C López-Mariscal (Technological Institute of Monterrey, Mexico), A R Moradi (Institute for Advanced Studies, Islamic Republic of Iran), A Nahal (Institute for Advanced Studies, Islamic Republic of Iran), M Nadasan ("Politechnica" University of Bucharest, Romania), A Serafíni (University College London, UK), A H Toor (Quaid-I-Azam University, Pakistan), C P Valdés (Universidad del Valle, Colombia), S P Walborn (Federal University of Rio de Janeiro, Brazil) and D N Yanyshev (M V Lomonosov Moscow State University, Russia).

This year, for the first time, a week of training at the school of mathematics was offered to selected participants, with the support of SPIE and the Italian Society for Optics and Photonics.

The academic and social interaction between the participants and lecturers is considered to be an extremely important aspect of the ICTP colleges. The three directors were especially grateful for the support and assistance given by the local organizer, Prof. Gallieno Denardo, and the secretary, Valerie Shaw.

In addition, the Trieste System Advisory Group for the advancement of optics in developing countries celebrated its annual meeting on 1 February and discussed the many relevant issues and activities to be initiated this year. On the same day the ICO/International Council of Science (ICSU) celebration took place (see *ICO Newsletter* January 2006).

The programme of the Winter College included the ICO/ICTP prize ceremony. The 2006 award was made to Dr Moya-Cessa of Mexico, a scientist and young researcher who has been pursuing his career in a developing country as defined by the UN (see *ICO Newsletter* January 2006).

The subsequent reception sponsored by the ICO provided a further chance, mainly for the young participants but also for more senior lecturers, to socialize and to celebrate with the ICO its recent admission as an international society in the ICSU. The reception was also attended by the current ICTP director, Prof. K R Sreenivasan.

For more information, see http://cdsagenda5.ictp.trieste.it/full_display.php?ida=a05190.

Adolph Lohmann celebrates his 80th year

A symposium was held in April celebrating the former ICO president's 80th birthday.

Prof. Lohmann and Prof. Haüsler, chair of the symposium.

The participants gather outside the second day's venue.

Adolph Lohmann, professor of physics at the Institute of Optics, Information and Photonics at the University of Erlangen-Nuremberg (Germany), former chair of applied optics and former ICO president (1978–1981), celebrated his 80th birthday in April. To mark this occasion his colleagues organized a two-day international birthday symposium entitled 50 Years of Information Optics. The event was held on 7–8 April, the first day at the University of Erlangen and the second in the charming region of Frankonian Swiss, located in Southern Bavaria near the Erlangen area.

There was a moving celebration in which all of the attendees, who came from all over the world, enjoyed the talks, anecdotes and scientific insights of their work that has been influenced and supported by Lohmann. Gerd Haüsler presented the welcome address and introductory sessions. He expressed his thanks to all of the attendees, and in particular to the chancellor of the University of Erlangen for the use of its facilities. He mentioned the great motivation of former students and friends to get together to honour the fruitful years of the academic and research activities of Lohmann.

Haüsler proceeded to introduce each of the session speakers: Gotthard Jasper, former chancellor of the University of Erlangen; Joseph Goodman from Stanford University; Asher Friesem from the Weizmann Institute of Tel-Aviv; and Jürgen Jahns from the Open University of Hagen. Jasper highlighted all of the important work done during the last 30 years that has contributed to building up a highly reputed international and prestigious group in optics.

In brief, Lohmann studied physics in Hamburg and later came to Erlangen. As an associate professor he started important work on the foundations and apodization techniques for his diploma. He then spent several years at the

Prof. Lohmann delivers the closing lecture of his birthday celebration.

Prof. Sinzinger presents the new edition of *Adolph Lohmann's Notes* to Prof. Lohmann, which was published as part of the birthday celebrations.

University of San Diego and initiated new and interdisciplinary work, becoming head of the optics group in Erlangen. One of his many international achievements is that he has been a recipient of the OSA Max Born Award. He is also a member of the Academy of Sciences of Germany. Lohmann has always remained highly devoted to his students.

Lohmann established the optics group in Erlangen in 1973 with a small laboratory, explained Haüsler. In only 10 years the number of researchers multiplied by a factor of 10. One of the recurring themes in Lohmann's work was "Is it possible to teach how to invent?", and this still provides motivation. In 1980 he started his work on computer holography, although there was some scepticism about this from part of the scientific community. However, this has turned out to be one of the most appealing technologies with significant applications in metrology and bio-optics, and it produces many industrial patents.

Goodman presented his talk entitled "New applications of speckles – or how Adolph Lohmann influenced my career". He mentioned all of the work done on computer-generated holograms, speckle masking, super resolution (1964) and theta modulation (1965). He then highlighted the most important results based on Lohmann's earlier publications: single side-band holograms (1956), detour-phase holograms (1966), and triple correlation, bispectra (1983) for improving telescope resolution and resolving double-stars images. Lohmann also developed pioneering work on Wigner distribution and fractional Fourier transforms, including a number of unpublished results. Lohmann, a devoted teacher, was quoted as saying: "I believe teaching optics is easy because it corresponds to a visual process." Lohmann is always a source of kindness and encouragement.

Friesem dedicated his talk to "Lohmann in the Holy Land", while remembering all of the extremely fruitful visits that Lohmann made to various centres in Israel. There he gave many lectures and seminars, and made visits to laboratories, thereby creating unique opportunities not only for scientific understanding but also for friendship – an important part of our lives that is sometimes ignored or misunderstood within the world of science.

Jahns referred in his presentation, "Optics in space and time with Adolph Lohmann", to the work done in Erlangen under his leadership, including annual reports for more than 30 years, referring to topics such as speckle, optical feedback, incoherent and coherent self-imaging, optical computing and photonic crystals. He mentioned the work done in collaboration with Goodman on fan-in, fan-out optical interconnections, fractional temporal Talbot effect, grating spectroscopy with new designs for temporal signal delay, compression and decompression. He referred to the recent publication of *Adolph Lohmann's Notes*, which was a present from all of his colleagues with the financial support of the University of Erlangen.

The talks were accompanied by some musical interludes, demonstrating the amazing sounds created by Bavarian orchestras and adding some colour to the proceedings.

On the following day the meeting continued in the unique atmosphere of a Bavarian village. The whole day was dedicated to short presentations from many of Lohmann's friends and colleagues who came from all over the world – France, Germany, Israel, Italy, Japan, the Netherlands, Switzerland, Taiwan and the US – including both scientific and miscellaneous aspects of their experiences as Lohmann collaborators.

Lohmann thanked all of the attendees, and gave a closing presentation with the amazing and suggestive title "Will optics remain schizophrenic forever?" After 60 years he was still posing the same question: "What is light?" He showed that his interests are beyond pure mathematics or physics, transcending to philosophical questions in a procession from Ptolomeus to Bohr, not forgetting Copernicus and Kirchoff. As an unforgettable end he suggested that after all, light is mainly Wigner stuff, it can behave as a fluid, although we do not need to know Wigner but, it is aesthetically pleasant.

With this modest but sincere article, ICO is honoured to have participated in this celebration. Mit unserem ganz herzlichen Glückwunsch zum Geburtstag!

María L Calvo, ICO secretary general

Argentinean Territorial Committee gets a new president

Prof. Hector Rabal is elected as the new president for the 2006–2008 period.

The Argentinean Territorial Committee has recently elected Prof. Héctor Rabal as its new president for the period 2006–2008. Rabal is a researcher at the Centro de Investigaciones Ópticas (CONICET-CIC) and professor of the University of La Plata.

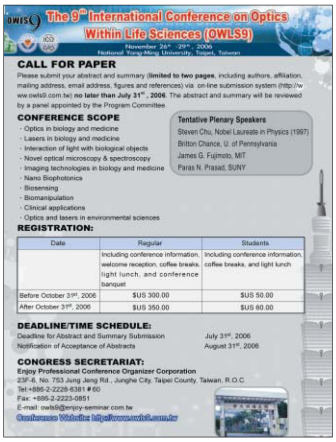
The ICO would like to express its sincere thanks and gratitude to Prof. Jorge O Tocho, also from CONICET-CIC, for the work that he achieved during his time as president of the Territorial Committee.

We warmly welcome Rabal and wish him a fruitful period in his ICO representation.

The ICO secretariat would like to encourage all Territorial Committees to send in their news to the *ICO Newsletter* in order to keep all of the ICO optics community updated on their recent activities.

9th OWLS Conference to focus on trends in biophotonics

The OWLS9 conference will be held in Taiwan on 26–29 November.


The 9th International Conference on Optics Within Life Sciences (OWLS9)

November 26th – 29th, 2006
National Yang-Ming University, Taipei, Taiwan

CALL FOR PAPER

Please submit your abstract and summary (**limited to two pages**, including authors, affiliation, mailing address, email address, figures and references) via on-line submission system (http://www.owls9.com.tw) **no later than July 31st, 2006**. The abstract and summary will be reviewed by a panel appointed by the Program Committee.

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- Optics in biology and medicine
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- Biomanipulation
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Tentative Plenary Speakers

Steven Chu, Nobel Laureate in Physics (1997)
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Paras N. Prasad, SUNY

REGISTRATION:

Date	Regular	Students
	Including conference information, welcome reception, coffee breaks, light lunch, and conference banquet	Including conference information, coffee breaks, and light lunch
Before October 31st, 2006	$US 300.00	$US 50.00
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The OWLS9 call for papers.

OWLS, the International Conference on Optics Within Life Sciences, is one of the principal forums for scientists, engineers and research students to exchange topical research and development information and to stimulate discussion about novel applications and concepts. Following previous OWLS meetings, the 9th International Conference on OWLS (OWLS9) – NYMU Biophotonics 2006 – will be an interdisciplinary event devoted to biophotonics and nanobiophotonics, covering all applications of optics and lasers in the life sciences, including biology, medicine, environmental science and clinical applications. The scientific programme will consist of invited and contributed talks, as well as poster sessions. There will also be a trade exhibition. The meeting starts on 26 November with two preconference tutorial lectures, one by Prof. P N Prasad (SUNY, Buffalo), who will give an overview of biophotonics and nanobiophotonics, and the other by Prof. James Fujimoto (MIT), who will speak about optical coherence tomography, followed by a preconference reception dinner.

OWLS9 has received financial support from ICO, an official sponsor of the OWLS9. This grant will be used to help scientists from developing countries to attend the meeting. Up to five scientists will be supported by the grant and they will each receive $400 for travel. In addition, the organizing committee will provide them with further support by waiving the registration fee and covering the cost of accommodation in Taipei during the conference for up to five nights.

Further information about OWLS9 (submission, registration, accommodation and travel support) can be found at www.owls9.com.tw.

Prof. Arthur Chiou (e-mail: aechiou@ym.edu.tw)

Contacts

International Commission for Optics (www.ico-optics.org).

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Forthcoming events with ICO participation

Below is a list of events with ICO participation that are coming up in 2006–2008. For further information, see www.ico-optics.org/events.html.

28–31 August 2006
8th International Conference "Micro- to Nano-Photonics" – ROMOPTO 2006. Sibiu/Hermannstadt, Romania. Contact: Prof. V I Vlad. E-mail: vlad@nipne.ro. Web: www.infirm.ro/ROMOPTO2006.

4–7 September 2006
ICO Topical Meeting on Optoinformatics 2006/ Information Photonics 2006. Saint Petersburg, Russia. Contact: Dr Alexander V Pavlov. E-mail: pavlov@soi.spb.ru. Web: http://ysa.ifmo.ru/tmo2006/.

26–29 October 2006
7th International Young Scientists Conference "Optics and High Technology Material Science" – SPO 2006. Kiev, Ukraine. Contact: Dr Viktor O Lysiuk. E-mail: lysiuk@univ.kiev.ua.

13–17 November 2006
1st Andinean and Caribbean Conference on Optics and its Applications. Santiago de Cali, Colombia. Contact: Prof. E Solarte. E-mail: esolarte@calima.univalle.edu.co.

3–10 December 2006
8th LAM Workshop on Physics and Applications of Lasers. Addis Ababa, Ethiopia. Contact: A Asfaw. E-mail: araya@phys.aau.edu.et.

6–8 December 2006
5th International Conference on Optics, Photonics Design and Fabrication – ODF '06. Nara, Japan. Contact: Prof. Tsuyoshi Hayashi. E-mail: hayashi@pac.ne.jp. Web: www.odf.jp/in.html.

12–16 December 2006
8th International Conference on Optoelectronics, Fiber-Optics and Photonics. Hyderabad, India. Contact: Prof. D N Rao. E-mail: dnrsp@uohyd.ernet.in.

17–19 April 2007
International Workshop "Tecnolaser 2007". Havana, Cuba. Contact: Dr J R Triana. E-mail: tecnolaser@ceaden.edu.cu.

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International Conference on Optics and Laser Applications – ICOLA. Yogyakarta, Indonesia. Contact: Dr Sar Sardy. E-mail: sardy@eng.ui.ac.id.

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ETOP 2007. Ottawa, Canada. Contact: Dr Marc Nantel. E-mail: marc.nantel@oce-ontario.org.

Responsibility for the accuracy of this information rests with ICO. President: Ari T Friberg, Royal Institute of Technology, Optics, Electrum 229, SE-164 40 Kista, Sweden; e-mail: ari.friberg@imit.kth.se. Associate secretary: Gert von Bally, Laboratory of Biophysics, Medical Centre, University of Münster, Robert-Koch-Str. 45, D-48129 Münster, Germany; e-mail: lbiophys@uni-muenster.de.

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