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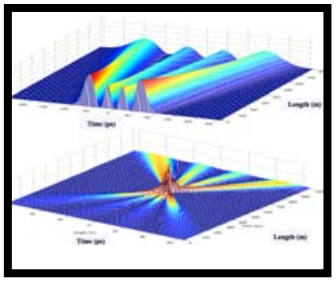
AUSTRALIAN OPTICAL SOCIETY



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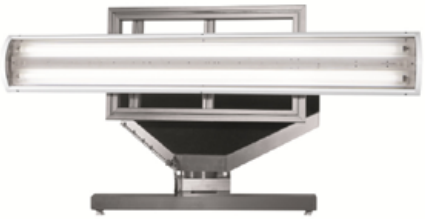

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AOS News is the official news magazine of the Australian Optical Society. Formed in 1983, the Society is a non-profit organisation for the advancement of optics in Australia. Membership is open to all persons contributing to, or interested in, optics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

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.

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 InDesign 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 (no page numbers), 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.

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.

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Articles

Departments

Cover Pictures:

- (Top) National Press Club Address by Professor Ian Chubb, Chief Scientist for Australia as part of the Science meets Parliament event, see page 9. Image credit: Lorna Sim/Science & Technology Australia.
- (Bottom) The Gala dinnner at Science meets Parliament, see page 9. Image credit: Lorna Sim/Science & Technology Australia.
- Insets (left to right)
  - Linear evolution of a complex pulse showing self-similarity, see page 27. Image credit: John Harvey.
  - The dress photo that sparked internet debate over whether it was blue and black or white and gold, see page 12. Image credit: swiked/Tumblr.
  - People gather around to watch haenyeo women divers in action on Jeju Island, Korea, see page 21. Image credit: John Canning.

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 CD will be considered.

Advertising:
Potential advertisers in AOS News are welcomed, and should contact the editor.
Rates: Under Review
Places may be booked for placing ads - this attracts a 10% surcharge. Black and White in main body of newsletter - free to corporate members.

Copy Deadline
Articles for the next issue (September 2015) should be with the editor no later than 14 August 2015, advertising deadline 7 August 2015.

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AOS News is the official news magazine of the Australian Optical Society. The views expressed in AOS News do not necessarily represent the policies of the Australian Optical Society.

Australian Optical Society website:
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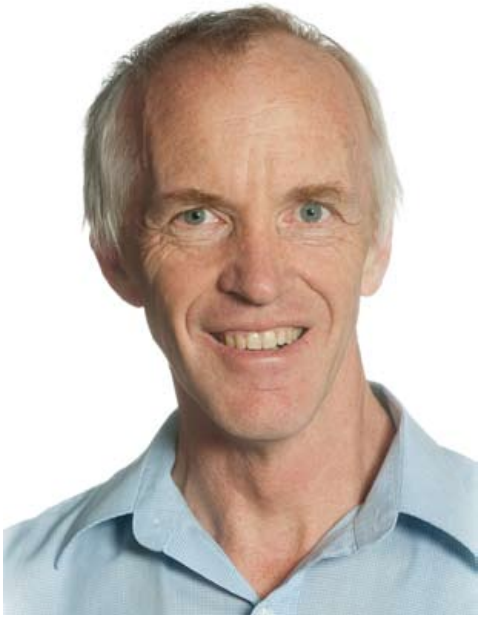
President's Report



At this time of year the research community, particularly for science and engineering, waits to see how the Australian government has dealt with the challenges of fostering research. Science & Technology Australia (STA), of which AOS is a member, described it as "some cuts, some lifelines in a mixed budget for science". Thus I'm sure AOS members were relieved that there was a reprieve for the National Collaborative Research Infrastructure Scheme (NCRIS), but highly concerned that certain university research funds were reduced to ensure this outcome. It was pleasing to see new funds were allocated to keep the Synchrotron operating in 2016/17, topping up the basic annual operating budget provided from the Victorian Government and the New Zealand Synchrotron Group. However, a cut from the Cooperative Research Centres program over the next 4 years, off the back of previous cuts and suspension of a funding round mid-way through, is less than welcome. AOS members seeking to pursue a research career would have been pleased that the Australian Research Council's Future Fellow scheme for mid- and early-career researchers is safe, although it is much delayed compared with last year. A medical research fund, despite uncertainty over how it would be funded, remains on the government's agenda.

Thus there is an ongoing need to highlight the role of technical areas for our nation's economic health, as well as other reasons. At this year's annual Science meets Parliament event, AOS was represented by our Honorary Treasurer, Baohua Jia (from Swinburne University of Technology). Australia's Chief Scientist Professor Ian Chubb has been actively championing this, through his recent report entitled "Science, Technology, Engineering and Maths (STEM): Australia's Future" and various talks around the country. No doubt AOS members were pleased that the need for a national, strategic, long-term plan for STEM has been identified and, to this end, another report by Ian Chubb that conservatively estimated the direct economic value to Australia of physics, chemistry, earth science and maths, as $145 billion per year - representing 11% of the economy, was welcome news. Additionally, in regard to possible future policies, STA CEO Catriona Jackson commented on the Opposition Leader's budget-in-reply speech "It is heartening to see a strong focus on Science, Technology, Engineering and Maths (STEM) as the drivers of a smart, modern Australian. It is also good to see some concrete policy proposals advanced to support the rhetoric".

Many AOS members would be aware of ongoing IYL 2015 activities through the year, and AOS Council is thankful for the efforts of one our Council members, Ken Baldwin, and team in ensuring that we make the most of this year, both to celebrate the wonders of light but also as a way to attract future students into light-based science and technology. I'm looking forward to visiting the "light in winter" program in Melbourne in June, and I hope other AOS members can participate in one or more such activities at some stage. Of course it's not too late for new initiatives for the latter part of the year. Council is well aware of the need for IYL2015 to have a lasting impact and, to this end, is considering the development of an updated "roadmap" for optics and photonics in Australia. As always, the ideas of members are welcome!

This year the annual meeting of AOS is being organised under the banner ANZCOP 2015, or the Australian and New Zealand Conference on Optics and Photonics 2015. ANZCOP 2015 is the second such conference, following the successful ANZCOP 2013 held in Perth. ANZCOP 2015 integrates two longstanding conference series, the Australian Conference on Optics, Lasers and Spectroscopy (ACOLS) and the Australian Conference on Optical Fibre Technology (ACOFT); 2015 will indeed be the 40th ACOFT. As in 2013, AOS is supported by Engineers Australia in hosting ANZCOP. AOS is pleased to have one of our Council members, Peter Veitch from the University of Adelaide as the General Chair, in conjunction with Andre Luiten (University of Adelaide) and John Arkwright (Flinders University) as the ACOLS and ACOFT Program Chairs, respectively. Thus can I encourage the Australian optical community to submit and present their work? It will be held at the University of Adelaide, from Monday 30 November to Thursday 3 December, and is likely to be preceded by an Industry Afternoon on Sunday 29 November.

Stephen Collins
AOS president

Editor's Intro

Welcome to another issue of AOS News. This issue was initially quite light on article submissions, so I am very grateful to everyone who managed to send something in. We do have a range of articles, with details of the recent Science meets Parliament event in Canberra as well as a response on the issue of 'The Dress'. There is a report from the recent APOS meeting in Korea and information about the upcoming conferences in Adelaide and Sydney at the end of the year as well as details of events that are running as part of the International Year of Light. Other items in this issue include an article from the winner of the 2013 AOS WH (Beattie) Steel Medal, John Harvey, on similaritons and our 'Optics in Everyday Life' section, which looks at the colour of electrons in this issue. I hope you enjoy reading them all. As usual, please let me know if you have any suggestions for anything you would like to see in AOS News or have any articles or other items you would like to submit.

The International Year of Light is well underway, and hopefully everyone will manage to take part in the Year in some way. There is a listing of selected events across Australia on pages17-18 and there is still time to plan your own Year of Light event. The Australian website (light2015.org.au) has full details of all events if you want more information or you can also check the international website (light2015.org). SPIE have run a photo competition for the International Year of Light and are looking for people to vote for the People's Choice Award. They asked me to contact as many people as possible to view the great images that have been submitted on the theme of light and vote for their favourite photo (spie.org/x110902.xml). The photos show light and light-based technologies in daily life, and depict issues such as light pollution, energy conservation, and sustainable energy, and celebrate our connection with nature.

I recently attended a presentation by Misha Ketchell, the Managing Editor of The Conversation, Australia's best-read research and news site, enabling academics to reach a wide audience through plain-English articles about their work. It is funded by a number of Australian universities and research organisations with the intent of helping academics translate their ideas to a wider audience and unlock the available knowledge whilst being free from commercial or political interest. They also aim to seed other media and have all content free to republish so that information can reach as wide an audience as possible, and have expanded so they also have bases in the UK, US and Africa. With the large shift to online media during the last decade it is ever more important that trusted sources of information are made available online, especially with the reductions in specialist journalists, such as science reporters.

Why write for the Conversation? It is important for the general public to have a good perception of science and scientists and for them to have some idea of what we do. As Baohua will have noticed when she attended Science meets Parliament this year, politicians act largely via lobbying and on areas that the general public care about. This means it is important for us to have dialogue of some kind with people so they see the importance of our work and science and research become issues that people care about. This can take many different forms and can involve paying attention and acting on social media or internet trends such as #The Dress or engaging with school students or community groups in organised outreach activities as well as things like contributing to The Conversation.

In trying to engage there is always the chance that things can go wrong - with the speed of the internet and news services a few ill-chosen words can spread around the world almost instantly, so it is important to be mindful of this. I was impressed that The Conversation started as an organisation that wanted to make sure there was commentary by experts in various fields that the experts themselves could check and have the final say on but that were on topics of relevance and interest to the general public and written for a wide audience. When being interviewed by the media there is always the chance for misinterpretation or an unintended slant to be given by the journalist, so the thought of someone who is there to help make an article interesting and readable but who won't change the meaning or misunderstand the science is great. I know many of our members already read and write for The Conversation, but if you haven't already done so I suggest you consider signing up and creating an author profile. You don't have to have an article or topic ready, and in fact most of their articles are sourced by their editorial team when they look for an expert to make an interesting article following news events. With a profile you'll be ready if you do see something in the news in your area of expertise or just want to correct misinformation, and you never know, the next expert they decide to contact could be you.

I hope you enjoy this issue of AOS News.

Jessica Kvansakul
Editor

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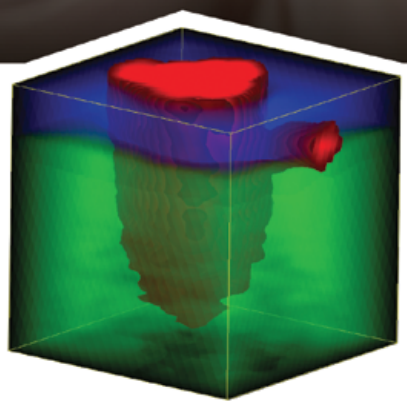

StreamLineHR Raman Image

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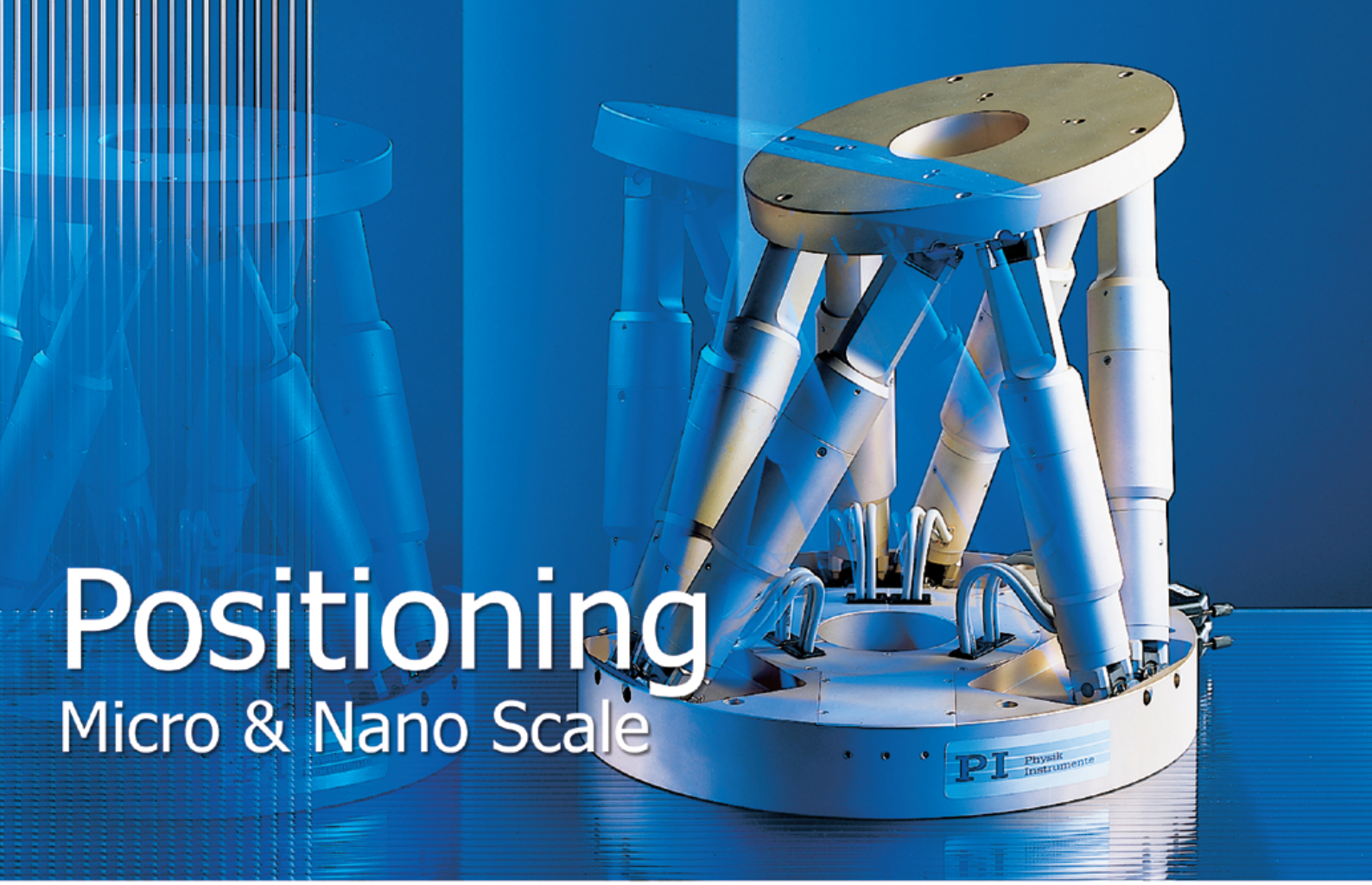

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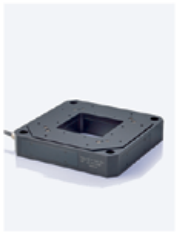

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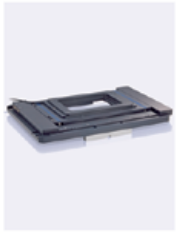

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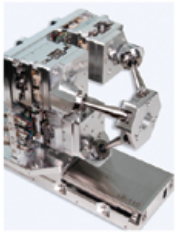

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Science Meets Parliament 2015

by Baohua Jia

All photos taken by Lorna Sim/ Science & Technology Australia.

Every year about 200 scientists from all over Australia are brought together by the Science meets Parliament event in the Capital city, Canberra.

Professors Hugh White (left) and Brian Schmidt (right) explaining to delegates 'How to talk/think like a policy maker'.

This unique event provides a valuable opportunity for scientists to show the parliamentary leaders how innovations address the major challenges facing the nation and why the government's policy and support are critical for the advancement of science and technology. It is also the chance for the scientists to learn the life of parliamentarians through a face-to-face meeting with one or two parliamentarians and practice their power to influence the decision making.

On March 24 and 25, 2015, sponsored by the Australian Optical Society, I was honoured to attend this annual event.

The event consists of a two-day program. On Day One, a number of guest speakers, including journalists, science communicators, advocates, and policymakers, provided valuable insights on the mysteries of the parliamentary and policy-making process as well as the life of a journalist. Topics like "Meeting the media", "The art of political meeting", "The messy nature of the policymaking process" and "Get your science out of the lab" were presented.

It is interesting and useful for a scientist, like me, to learn of these different lives. It helped me to understand different languages and develop skills to better communicate research outcomes with politicians, journalists and more broadly the general public. It was a surprise to me to find out that journalists were actually looking for good stories rather than having too many of them. So as scientists, we should feed our exciting stories to them and let them spread the word about the wonder of science.

The presentations, talks and discussions on Day One were very well organised and made the attendees well-prepared for the Day Two event, which is the meetings with the parliamentarians. One talk I enjoyed most was from Professor Brian Schmidt on "How to talk/think like a policymaker".

The Gala Dinner was hosted in the Great Hall at Parliament House. It was great fun to meet the nation's top parliamentarians, including the Industry and Science Minster Ian Macfarlane and Opposition Leader Bill Shorten during the Gala Dinner. I enjoyed the conversations with my fellow scientists who shared the same table with me. Although they work in completely different research fields, it is wonderful to find out how research innovations can advance science and technology in diverse ways.

The gala dinner took place in Parliament House on Day One of the meeting.

Day Two came with the really exciting part of this event - face to face meetings with the parliamentarians.

In the early morning of March 25, the Australian Academy of Science released the report, entitled "The importance of advanced physical and mathematical sciences to the Australian economy", which was commissioned by the Office of the Chief Scientist and the Australian Academy of Science and produced by the Centre for International Economics (CIE). It details how physics, mathematics, chemistry and earth sciences benefit the Australian economy. I was thrilled to find that advanced physical and mathematical sciences make a direct contribution of around $145 billion a year to the Australian economy (~11 per cent of GDP), as shown in Figure 1. This is a magnificent achievement for all the people working in the relevant fields, which we should be proud of and celebrate. This timely report became one of the key messages I planned to convey to the parliamentarians on Day Two about the importance of government's support towards fundamental research.

I was lucky to have two face-to-face

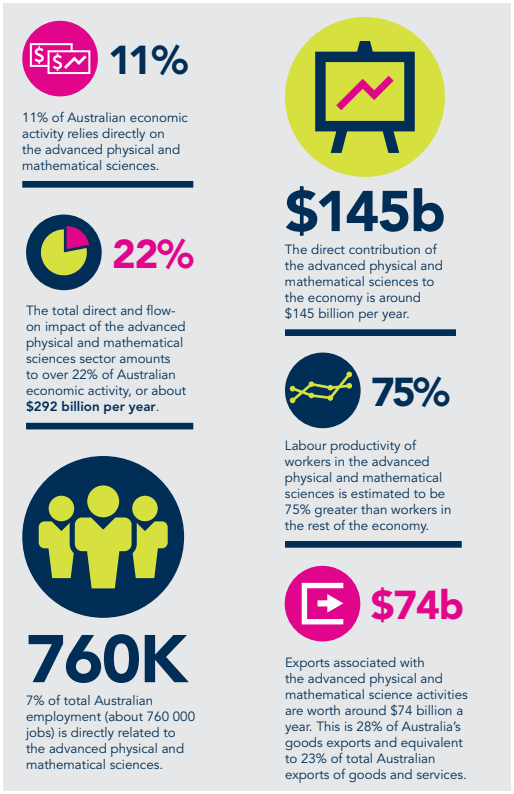

Figure 1. Image taken from the "The importance of advanced physical and mathematical sciences to the Australian economy" report by the Centre for International Economics for the Office of the Chief Scientist and the Australian Academy of Science.

meetings arranged with Mr Rob Mitchell, Federal Member for McEwen, and Senator Chris Ketter for Queeensland, respectively. Based on their background and interest as well as my research expertise, I presented to them two different topics on renewable energy storage for electrical cars and photonics for renewable energy. The two key messages I conveyed were the increasing importance of photonics in our social and economic life, mentioning the International Year of Light in 2015 and the critical role of sustainable government support towards fundamental research, mentioning the Report from the Australian Academy of Science. The messages were well received, in particular the second one, and both parliamentarians echoed the driving role advanced physical and mathematical sciences have played in the economy and acknowledged the importance of long-term support from the government.

In addition to the face-to-face meetings, the other highlight on Day Two was the National Press Club Address by Professor Ian Chubb, the Chief Scientist for Australia. The title was "Aspiring to something magnificent". I have been a big fan of Professor Chubb since a couple of years ago. Although due to the scheduled meetings with the parliamentarians, I could not attend his speech in person. I watched the live show on TV. It was a great pleasure to watch the inspiring, humorous and far-reaching speech he gave. It made me further realise the critical role science plays in the world. I was grateful that I am working in a field that could produce some positive impact to people's lives.

The Science meets Parliament event ended up with a cocktail session, in which we enjoyed the last networking opportunity with our new friends.

This two-day event was very different from normal scientific conferences. It has been one of the most enjoyable and memorable events I have attended.

Opposition leader, Bill Shorten addressing delegates at the Gala dinner.

National Press Club Address by Professor Ian Chubb, Chief Scientist for Australia on "Aspiring to something magnificent".

Instead of meeting peer researchers in the same field, this event provides an opportunity for scientists to meet with the top politicians and journalists. Through understanding how politics, policymaking and the media work, the scientists can play a better role in communicating their science with the media and politicians, thus better influencing the policymaking process. On the other hand, it also helps the parliamentarians to better understand the importance of scientific work to Australian economics and society, thus better supporting science.

Baohua Jia is with the Centre for Micro-Photonics, Swinburne University of Technology.

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What Colour is a #Dress?

by Simon J Cropper

Earlier this year there was a large amount of internet interest in the colour of a dress in a particular image. Here is a response from a vision scientist who had to comment on this issue in the media.

"Mere colour, unspoiled by meaning, and unallied with definite form, can speak to the soul in a thousand different ways." Oscar Wilde

The representation of colour in the world we experience has been the subject of debate and introspection for centuries. The colour red is synonymous with blood, life, death and revolution. Blue is associated with cold and sadness, dehumanising nature more than any other colour (according to Nietzsche) whilst being oddly rare in the natural environment. Yellow is sickly, golden and the gilt of royalty; green is envious, the colour of chlorophyll - the root of humanity. Artists, philosophers, neuroscientists and psychologists find common ground in the discussion of the experience of seeing colour, and of all aspects of vision it is the most likely to arouse interest (and lust*) in the scholar, student or casual acquaintance.

Despite this universal appreciation of the sense of colour, and the wealth of quantitative data on the neurophysiology and behaviour of the visual system, we lack a sound coherent framework in which to place the wide range of experiences we associate with our colour vision.

These two points were effectively highlighted through the recent global discussion about the colour of a striped dress [1,2]. This Twitter-fuelled discussion has become variously known as "That Dress", #TheDress and, disturbingly enough, #Dressgate. Rather than repeat the many popular articles that have been written about the argument surrounding the colour of the dress, one of the better ones at the time being in Wired [3] as well as many local commentaries, I will try to give a personal and scientific overview of the 'trending' blip in the Twittersphere, momentarily taking the place of puppies dancing or gladiatorial renovation wars. The 'debate', and I place that in quotes as it really was more of a series of enthusiastic assertions, has culminated in three research papers in the upcoming issue of Current Biology [4,5,6] and a series of demonstrations and the appearance of the real Dress at the Vision Sciences Society Conference in Florida that I attended last week.

The first I knew of this discussion, not being on Twitter myself, was my PhD student testing me at 8am on 27th February, 2015, asking me what colour I thought a dress was in a photograph she had attached. My first thought was what was she doing shopping at that time in the morning and why had she taken 24 first year psychology students with her (who apparently wanted to know the answer). It turns out she was taking a tutorial and one of the students had seen the Tweet. Two hours later one of my former students who worked as a fashion journalist at a Sydney newspaper called me for a comment. What followed, for my and many of my colleagues, was a day of talking to various media outlets for comment on something that, to be perfectly honest, struck most of us as the epitome of a First World Problem.

It was, however, quite gratifying that a basic question about human colour vision was creating so much global interest (if only the ARC would take note of this) and was clearly not something with a simple veridical answer: most informed experts, whether optometrists, psychologists or neuroscientists were giving very similar accounts and concluding that we do not really know why there is such disagreement over this.

The following week, the colour and vision newsgroup, which almost universally limits itself to job adverts and conference announcements suddenly had a scientific debate on its hands and people actually got involved. Many of us were more excited by the general involvement of our colleagues worldwide than we were by the question itself. That same week I was due to give the introductory lecture(s) to 1312 first year psychology students, so I thought I might see what they thought of the whole #Dress issue. I put the original photo up about 10 minutes into the lecture and of all the demonstrations and examples I have put up in over 10 years of lecturing to more than 10,000 students I have never had such a response. It took about 5 minutes to calm them down. I then attempted some rudimentary analysis of what they saw, whether it was age- or gender-biased (it wasn't) and whether there were really only two optional percepts (there were at least 4). It was then I realised that there was something quite important about this debate and the global interest in finding the answer, or at least observing that there was not an easy one; and this, above all, was what we, as scientists, needed to exploit.

Figure 1. The dress photo that sparked debate over whether it was blue and black or white and gold. Photo: swiked/Tumblr.

Predictably the general interest in the perceived colour of a dress was soon usurped by dancing puppies etc but the debate and interest amongst scientists endured for a while longer, and has produced at least three peer reviewed studies [4,5,6], and probably will spawn several more. The outcome of these three studies has provided support to the original comments made at the time; put simply, we do not know the answer. This has been relayed in the general media [7,8] which I find reassuring. I think it is critical that the general population know what little we actually know or are sure of, for it is only then they will realise how much more we have to do to understand how the brain performs even in its simplest tasks.

To summarise, #TheDress became such an issue for a variety of reasons, both because it is indeed a multi-layered problem from the perspective of vision science, but

* "Colour is the femme fatale of vision. When once seduced, you will never be a free man again." Ragnar Granit to William Rushton

Figure 2. Lighting often affects the perceived colour of objects in photos as seen here. Left is a full body shot showing a blue suit, right is a close-up of the same suit where it appears very different due to the bright background lighting.

also because of the confounding factors of social media and language.

Firstly, the question asked was "What colour do you think this dress is?" referring to the photograph, taken on a phone. So the question itself was ambiguous from the outset, or at the very least required extrapolation from a low-resolution photograph to the real world. The response was also primed to be one of two options (black and blue or gold and white), implying the response was binary in its nature. This then coloured, for want of a better word, all subsequent data. Language is limiting in its description of colour even when you stray outside the 11 basic colour terms. Furthermore, there is growing evidence that the so-called categorical nature of colour is only evident when you involve the restricting influence of language in the response [9].

Secondly the photo itself was affected by several different sources of light and glare, which the phone camera attempted to correct for and in doing so manipulated the colours in the result. I accidentally discovered this process for myself when suit shopping (fig 2). The full body shot is a reasonable representation of the colour of the suit I was trying on. The close up is the same suit but a close up of the fabric on the sleeve; the bright background is very similar to that in the dress photo.

In the case of the dress this physical property of the stimulus was then further modified by the different devices that people viewed the picture on across the internet. These factors alone could explain the disagreements in different locations and times, but people were still arguing while looking at the same picture in the same place at the same time on the same device.

From a physiological and psychological perspective, the problem is ill-defined in terms of the question and the uncontrolled stimulus, but also the question is, more generally, about an aspect of the visual experience, colour, that is incredibly sensitive to context and ill-defined even when using specific colour terms. It is also the case that each system (person) viewing the photo is unique, from the photoreceptor mosaic onward, and everyone does see their own version of the world. In terms of individual differences, the fact that short-wavelength light is involved in the percept (the blues and whites (which are very 'cornflower blue')) exacerbates the possibility that people really will see different colours. There are far fewer short-wavelength (S) sensitive cones in the retina, yet they have a disproportionate effect on colour perception. This increases the likelihood of measurable perceptual consequence of slightly different S-cone numbers between individuals. As an example, how often do you argue over the pink-purple colours? A few more S-cones and you will see purple when someone else sees pink.

The scientific approach to the question of how we see is to take a particular visual stimulus and to quantify the behaviour of the organism, or output of the neurone, in terms of the properties of the stimulus. The philosophical question of 'what is the world?', however, tends to be overlooked by referring back to the stimulus when assessing the performance of the system, or of any particular model or theory. If one seriously entertains the possibility that the perceived world is a construction of the brain*, then this constant reference to the input becomes less tenable. What we do know about the components of the visual system and its operation at the most gross of levels suggests that contact with the image projected on to the retina is lost almost immediately and the world we perceive is indeed a construct of the operation of the system. Whether it is a faithful representation of what is 'out there' is probably less important a question than what this loss of contact with the image means for the operation of the system and the potential and freedom that this dissociation offers the mechanism of operation. It also increases the likelihood of individuals experiencing significantly different versions of 'the world'; #TheDress.

At this stage, with the recent publication of data on the issue, it is worthwhile considering what we have learned from this kerfuffle. I think the interest of the general public in genuine scientific debate and discussion of the things we do not know about the world we experience is massively underestimated. Governments like to tell us that people ('the taxpayer') are only interested in something that saves lives or makes money, I think that #TheDress has shown an alternative view. Furthermore I think that this is what we have to use to our advantage to get science and the fascination of the unknown back into the day to day discussion of the general public. My students initially hate it when I tell them how little we know, then they love it that there is so much to find out and work with, and that the brain remains a genuine mystery that we may never solve. Perverse quirks of the Twittersphere like #TheDress remind us of this and that it is not so hard to make it accessible to everyone. I have even considered getting a Twitter account, which is not something I would ever have expected to be saying, let alone writing.

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* "The apparent world and the true world means - 'the world' and 'nothing'" Friedrich Nietzsche (after Bishop George Berkeley)

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Events

20-22 July 2015 WOMBAT

The Workshop on Optomechanics and Brillouin Scattering: Fundamentals, Applications and Technologies will be held in Sydney from 20 to 22 July 2015. This workshop will bring together international expertise in the field of physics and applications of optoacoustic interactions, creating a bridge between classical and quantum aspects of optomechanics and Brillouin scattering. cudos.org.au/wombat

31 August - 4 September 2015 COLA 2015

The 13th International Conference on Laser Ablation will be held in Cairns, Queensland from 31 August to 4 September 2015. Laser ablation encompasses a wide range of processes of laser interaction with matter, from delicate atomic motion in transient states to acceleration of particles to extreme energies. These processes present many challenging problems for scientists to study and understand. At the same time, laser ablation is of significant commercial importance in material processing, constituting today a multi-billion dollar industry. These topics, together with new emerging physics of laser interaction with matter and its applications for laser modification of material properties will be widely addressed at the conference. cola2015.org

22-27 November 2015 IONS-KOALA 2015

KOALA (Conference on Optics, Atoms and Laser Applications) is Australia's only student conference in the fields of optics, quantum optics, atom optics, photonics and laser technology and will be held at the University of Auckland from Sunday 22 to Friday 27 November 2015. ionskoala2015.osahost.org

29 November - 3 December 2015 ANZCOP 2015

The Australia and New Zealand Conference on Optics and Photonics 2015 will be held at the University of Adelaide from 29 November to 3 December 2015. It integrates the Australian Conference on Optics, Lasers and Spectroscopy (ACOLS) and the Australian Conference on Optical Fibre Technology (ACOFT), and ANZCOP 2015 is the second such conference, following the successful ANZCOP 2013 held in Perth. ANZCOP 2015 will include a wide variety of plenary talks, including the Advanced LIGO project and the latest developments in bio-photonics, and a plenary by the 2015 Frew Fellow: Professor Ursula Keller of ETH Zurich. Abstracts due 31 August 2015. anzcop2015.com.au

6-9 December 2015 SPIE Micro+Nano Materials, Devices, and Applications

The SPIE international symposium on Micro+Nano Materials, Devices, and Applications will be held at the University of Sydney from 6 to 9 December 2015. This biennial conference will be a multidisciplinary forum with a focus on research that has enabled promising new materials and applications across many fields, including photonics, energy, security, information, and medicine. The symposium is an interdisciplinary forum for collaboration and learning among top researchers in all fields related to nano- and microscale materials and technologies. This event will focus on nanostructured and biocompatible materials, medical and biological micro/nanodevices, micro/nanofluidics and optofluidics, nanophotonics for biology and medical applications, plasmonics, solar cell technologies, and fabrication. Abstracts due soon. spie.org/AU/conferencedetails/micro-plus-nano

7-11 February 2016 ICONN 2016

The International Conference on Nanoscience and Nanotechnology 2016 will be held at the National Convention Centre, Canberra from 7 to 11 February 2016. The aim of ICONN 2016 is to bring together Australian and International communities (students, scientists, engineers and stake holders from academia, government laboratories, industry and other organisations) working in the field of nanoscale science and technology to discuss new and exciting advances in the field. ICONN will cover nanostructure growth, synthesis, fabrication, characterization, device design, theory, modeling, testing, applications, commercialisation, and health and safety aspects of nanotechnology. Abstracts due 20 September 2015. ausnano.net/iconn2016

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The Light, Energy and Environment Congress is comprised of four meetings, and is the continuation of the congress held in 2014 in Canberra.

See each meeting for details regarding topic categories, submission requirements and invited speakers.

- Optical Nanostructures and Advanced Materials for Photovoltaics (PV) osa.org/pv
- Optics for Solar Energy (SOLAR) osa.org/solar
- Optics and Photonics for Energy & the Environment (E2) osa.org/e2
- Solid-State and Organic Lighting (SOLED) osa.org/soled

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INTERNATIONAL YEAR OF LIGHT AUSTRALIA 2015

The Year of Light in Australia is now underway, with a wide range of activities happening around the country. The list of events, festivals and activities celebrating light for the Year is quickly growing. You can submit details about your own events or read the full calendar at light2015.org. Below are details of selected Year of Light events.

The International Year of Light Australia 2015 is supported by the Australian Optical Society, the Australian Institute of Physics, CUDOS and the Astronomical Society of Australia.

Upcoming Year of Light Events

27 June, 22 August, 24 October, 19 December 2015 Mt. Stromlo Observatory Site Tours, Canberra
Take a walking tour of the Mount Stromlo Observatory and learn about the history, the science, and the future of Mount Stromlo Observatory. rsaa.anu.edu.au/news-events/mt-stromlo-observatory-site-tour-4

3, 10, 17, 24, 31 July, 6.30 - 8pm July Lectures in Physics, Melbourne
The University of Melbourne is running its July Lectures in Physics 2015 on the theme of The International Year of Light. Topics are: Understanding light: from the Arab scholars of the 11th Century to Maxwell and Einstein, by Professor David Jamieson. Nanoscale light: The surprising world of optical nanostructures by Professor Ken Crozier. Prospecting with light: The search for supermassive black holes in galaxies, by Professor Meg Urry. Distant light: Reading the signals from the oldest light in the Universe, by Professor Stuart Wyithe. Light and matter: Bending light waves for new technology by Professor Ann Roberts. physics.unimelb.edu.au/Community/Newsroom/Events

11 August, 5.30 - 7pm Light Technology and Defence, Adelaide
The Defence Science & Technology Organisation (DSTO) and the University of Adelaide's Institute for Photonics and Advanced Sensing (IPAS) will be hosting a joint event as part of the IYL. The production, manipulation and measurement of light in all its forms is a key part of defence science. Speakers from both organisations will present the latest on how light-based technologies are helping to provide leading edge capabilities in areas such as infrared imagery, fibre optic hydrophones, and optical communications. blogs.adelaide.edu.au/researchtuesdays/

14 August - 15 November Light Play, Queensland
This exhibition at the University of Queensland Art Museum considers the work of contemporary artists who employ light and related technologies, and examines their practice in relation to artistic precedents. Light play, which coincides with the International Year of Light and Light-based Technologies, features artworks by artists who use light as a medium in its own right, to create their work or its effects, or to explore socio-political concerns. artmuseum.uq.edu.au/content/light-play

21 August, 6 - 9pm Guinness World Record attempt – most people stargazing in one place, Canberra
Mt. Stromlo Observatory will be leading Australia in attempting two Guinness World Records – Most People Stargazing at a Single Site (Mt. Stromlo) and Most People Stargazing Across Multiple Sites in a Country). Please invite all your friends and family in Canberra to help us reach our target of at least 2,700 people. You can either bring your own telescope or there will be

Mt. Stromlo Observatory is offering tours as part of IYL and holding a World Record attempt. Photo Credit: Dr. Paul Francis (Mt. Stromlo Observatory, ANU).

small, commemorative telescopes (about the same size Galileo used!) available for before the event via your local representative (anticipated cost is a gold coin donation). Warm clothing is recommended.

There will be a wide range of telescopes at the site, operated by Astronomers, where guests may be able to view the craters of the moon as well as beautiful star clusters and nebulae. In addition, there will be talks by a range of astronomers from Mt. Stromlo Observatory, including Profs. Brian Schmidt and Lisa Kewley. facebook.com/events/1007785492583934/

22 August, 5 - 9pm Astronomy and Light Festival, Melbourne

Mount Burnett Observatory and Telescopes in Schools have come together to put on a huge Astronomy and Light Festival for the Melbourne public at Scienceworks during National Science Week. The festival will be a showcase of Australian Astronomy and Light in conjunction with the International Year of Light. Contributors and sponsors of the event are coming together on this evening to share the wonders of light. Plenty of fun and interesting activities for all ages. aliv2015.wordpress.com/home/

INTERNATIONAL YEAR OF LIGHT AUSTRALIA 2015

News

David Coutts, new director of MQ Photonics, Macquarie University

Prof Mick Withford has relinquished his role as MQ Photonics Director after serving for six years in this role. The incoming Director of MQ Photonics is well known to the optics community, Assoc. Prof. David Coutts, who assumed the role of Director effective from May 1st, 2015. David has strong leadership credentials, as a former Head of Department, elected member of University Senate, Deputy Director of MQ Photonics, and current Deputy Associate Dean for Research. Both Mick and the inaugural Director, Prof Brian Orr, continue at MQ within the Centre and Department of Physics and Astronomy.

David Coutts is the new Director of MQ Photonics.

Celebrate light, make a photographer's year: cast your vote for the People's Choice Award in the SPIE International Year of Light Photo Contest

Voting is open now online for the People's Choice Award in the SPIE IYL Photo Contest. The winning photo will receive a prize of US$500, and voters who register have a chance to win a GoPro camera. The SPIE IYL Photo Contest received more than 800 images. An international panel of executive and student judges selected the top 35 photos after evaluating all on scientific interest, creativity, and how well the photo communicated the contest theme. The top three images have already been chosen, with the final prize remaining being the People's Choice Award.

The 32 dazzling finalist photos portray light and light-based technologies in daily life - LEDs, solar panels, adaptive optics, and lasers - and in doing so promote multiple solutions to global challenges in energy, education, security, agriculture, and health. The photos depict issues such as light pollution, energy conservation, and sustainable energy, and celebrate our connection with nature.

People's Choice voting runs online until 15 August.
http://spie.org/x110902.xml

The Constant, by Jasper da Seymour, Mystery Creek Cave, Tasmania is one of the finalist photos in the SPIE IYL Photo competition.

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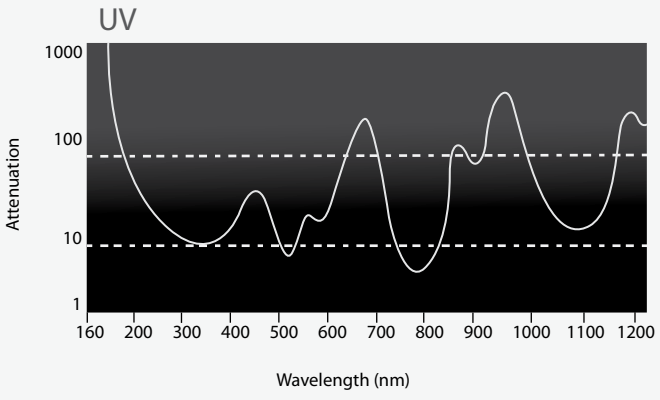

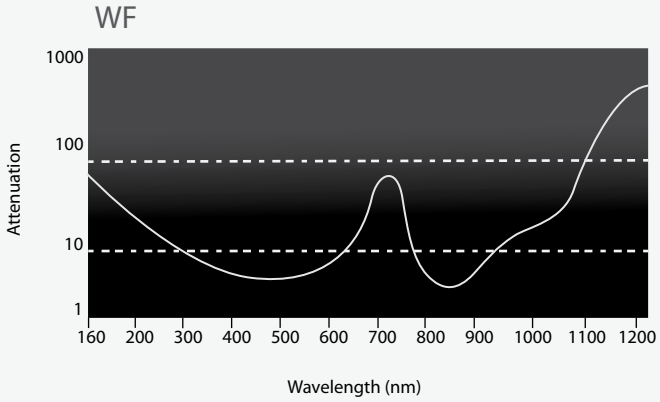

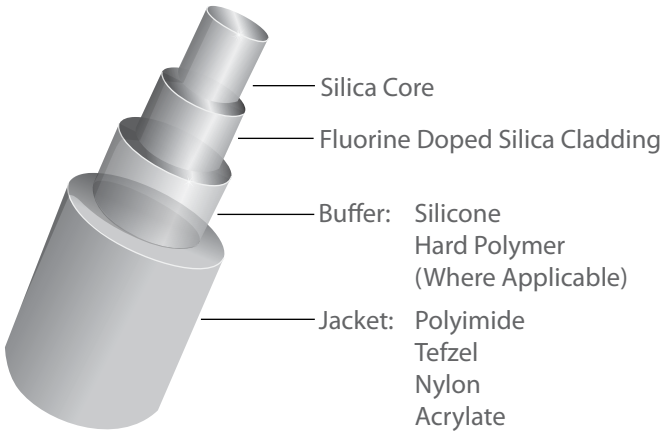

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Light Conferences with Heavy Messages

by John Canning

100 must-see photonic conferences before one dies? I pondered this macabre challenge, with a hint of humorous sentimentality, whilst clambering over the rocks and contours of a photon-deficient lava sill of an (hopefully) inactive volcano in Tamna guk Korea where I was attending the Asia Pacific Optical Sensors Conference.

Anyoung haseyo colleagues! Greetings from Korea. As many of you in the community know, amongst the overwhelming number of new conferences, there are certain conferences that remain the staple of optical sensing and devices. I focus on optical sensing because many things we take for granted were outcomes from sensing work. For example, the optical fibre was first developed in bulky multimode form for imaging inside body cavities and later TV transmission well before launching the telecomm revolution. This is in part due to the longevity of sensing but also due to the cross-disciplinary nature and scope, spanning fundamentals to applications across so many areas. As well as monitoring new advances in the field and elsewhere, these conferences carry that history of maturation associated with platforms that are surviving the test of time. In this light the two distinct and international key events are the independent Optical Fibre Sensors (OFS) Conference [1] and the OSA Bragg Gratings, Photosensitivity and Poling in Glass Waveguides (BGPP) Meeting [2], the former perhaps more focussed on applications and the latter driven more by fundamentals.

OFS will be in Brazil this year [1], marking the 24th event hosted every 1.5 years or so - you can work out yourself the longevity of the event. Many of the co-founders have since retired although many remain on the International Honorary Committee list in recognition of their vintage. This conference has seen significant development and growth alongside the evolution of modern optical fibres although it is not entirely limited to these particular waveguides. OFS in Santander Spain last year saw record numbers: more than 500 attending. This year those numbers are unlikely to be equalled given the remoteness and distance of Curitiba in Brazil, in spite of the must-do stopover in Rio, but there is no doubt key breakthroughs will be presented. I should add that participation numbers have been estimated and China now leads with the highest participation rate for nearly all these sensor events.

Although with any long term events there are always questions of direction and how one captures new trends, the clear growth in applications across many sectors (of which oil and gas are presently dominating) reflects maturation and growth in optical fibre sensing. Consequently, an obvious area of increasing importance is standardisation and industry-specific certification of these technologies.

A very significant change that is occurring is the global shift of where research and development is being undertaken. Today, most applications of optical sensing are being field-tested in China and in Asia on a scale that surpasses anything we have seen before. In fact, one of the first (if not the first) true global field assessments of a genuine optical fibre sensor system – the optical fibre current sensor – was led and undertaken by the Beijing Power Transmission Company. Fifteen (yes *fifteen*) companies within China and two from overseas (from the United States and one from Australia - Smart Digital Optics, SDO which has been acquired by the Spanish power engineering company Arteche) competed. Although not publicly announced, all companies failed the first round of testing - Australia's SDO was the first company to pass and fully qualify in subsequent testing. This is quite an extraordinary outcome but there is no doubt that the perseverance of our local colleagues at SDO over more than 20 years has trumped the massive investments that have gone into much shorter term efforts overseas. These kinds of international field trials remain few and far between (and are certainly not at all well reported) although it was noted at OFS that the drive for international standards exists, at least for optical fibre pressure and temperature sensing. The next OFS after Brazil this year will be in Korea in 2017.

I mention this specific example precisely because it is a symbolic - no, more than symbolic - measure of the regional power shift in optical sensing that has taken place. There are many other examples spanning structural health monitoring, aerospace, biosensing and so on. Consequently, it is no surprise that a regional complementary conference to OFS has been formed - the Asia Pacific Optical Sensors Conference (APOS). It is held in alternate times with OFS, optimising a unique partnership that began in Chengdu, China in 2008, later held in Guangzhou, China before its first international debut in Sydney, Australia in 2012. The latest event was held this year (in May) in Jeju Island in Korea [3] and the next will be in Shanghai, China

Figure 1. Korean seafood feast. From Left to right: Prof. Youngjoo Chung (APOS TPC Chair), Prof. Hartmut Bartelt, Prof. Anna Mignani and Dr. Silvia Huguet.

Figure 2. Local comedy and dance group perform NANTA! at the conference banquet - two international guests were subsequently humiliated in a mock Korean wedding comedy routine.

in 2016. Highlights spanned optical fibres (Prof. Cicero Martelli's timely reminder of the role of certification indicating the kind of research that leads to real optical fibre sensing as opposed to more journal papers) and bulk optics (A/Prof. Anna Mignani demonstrated work on compact, novel bulk optical colorimeters and spectrometers deployed in agricultural sectors). There were three plenaries of which one was given by an Australian, Prof. Min Gu on using air-clad fibres for multiphoton fluorescent microscopy. This has become the most important event in the region for both optical fibre and optical sensors, from a fundamental to an applied level. After Shanghai it will go to Japan. Tentatively, led by Dr. Frederique Vanholsbeeck from Auckland University, we are working towards bringing it to New Zealand following Japan - advanced planning is everything!

As significant as these events are, BGPP brings something extra special - it is the home of fundamental research in understanding and utilising glass change, particularly that involved with waveguide fabrication and laser processing. It has a long and unique history guided strongly by genuine opportunities underpinned by fundamental insight. In its early days it was complemented by alternate European summer schools (Vitzneau Switzerland, Riveria France and St. Petersburg Russia) explaining in depth photosensitivity and glass change in a series of lectures for students and researchers. These lectures were important in avoiding repetitive misunderstandings in the field. Sadly, the effort to overreach those summer schools beyond photosensitivity quickly diminished them until they were vanquished - talk continues to try and bring these back again, the matter made more urgent by the re-emergence of a growing body of discredited work. Almost as ubiquitous as optical fibre itself are fibre Bragg gratings and BGPP was the place most major breakthroughs are reported, including the first multi-photon grating writing in glass using two photon UV light. Today, the advent of femtosecond lasers has seen a tremendous new capability in grating writing (and indeed in component manufacture) based on extending and localising multiphoton absorption into the near IR where most relevant glass materials are transparent. Despite the differences in degree of wavelength and timescale, many of the fundamentals remain the same - for example, we have demonstrated similar regeneration is possible in UV and femtosecond processed glasses because both processes involve non-equilibrated glass, even when void formation arising from very rapid glass condensation under stress and reduced co-ordination occurs. Attosecond lasers are likely to further the possibilities in terms of temporal separation, and freezing in, of processes. A key role of BGPP remains elucidating all these mechanisms, their details and how these can be exploited not only for immediate applications but for a new generation of technologies, including 3D laser printing. There are also many other fundamental topics, much around the design and fabrication of glasses for post-tuneable non-linearity - novel thermal and laser poling in custom waveguides may be seeing a resurgence with the ongoing need for low loss devices. As well BGPP often serves to explore component properties and their optics to a depth not explored elsewhere. For completeness, BGPP welcomes applications, especially those that are tied to their fundamental properties and to the need for international standardisation. For your voluminous cloud diaries, the next BGPP will be in Sydney, Australia in 2016.

As International Steering Committee member for these events and Chair for BGPP next year, I strongly encourage everyone to participate. OFS will be in Curitiba this year in Brazil, APOS will be in Shanghai next year and BGPP will be much closer to home in Sydney - what a trifecta in Photonics (I can see the warming hands and gleefully dribbling/salivating mouths on you already)! In fact BGPP will be co-located with the Australian Conference on Optical Fibre Technology

Figure 3. People gather around to watch haenyeo women divers in action on Jeju Island, Korea. With an average age over 60 this long, but arduous, tradition may soon disappear. The next OFS in 2017 will be held on Jeju – the last chance to see them?

(ACOFT) and the Nonlinear Photonics Workshop, most likely all three as part of an Optical Society of America Congress, working with the AOS, although details are yet to be finalised and announced to the community.

2015 has been selected as the International Year of Light - I won't bore you with the many events associated with that because others will, but it is worth bearing in mind that it could just as easily have been the Regional Year of Light given the enormous shifts in scale where photonics is being applied. I am reminded of being atop of the as-yet completed Hemmel and Kuit Canton Tower in 2010 at the second APOS as it swung wildly from side to side, being shown where the fibre Bragg grating sensor modules were pitched against conventional sensors. The attempts to make real systems are certainly furious and fast-paced. Australia lies nearby much of the action (it is in fact part of it) and strategically is well positioned to be the global photonics middleman "consultant expert nation" as well as key technology player both academically and commercially, something I note could have been highlighted in our Chief Scientist's general report on the role of science and technology in Australia. The relevance of manufacturing to optical sensing and vice versa, including increasingly on the nanoscale, is central. Our ability to hold these conferences and to manage them off-shore not only keeps us engaged and up-to-date, but it reflects our international diplomatic leadership role in the field of photonics, and the respect and high regard in which Australia is held. To end on a cautionary note, it comes at a time when potentially partisan legislation, as well as other tensions, has been introduced that may create some anxiety for our future in the region and therefore our economy [4], underpinning the tip of the iceberg already rearing its ugly head in our media. Our community must therefore work closer than ever before.

Haenguneul dama dear colleagues!

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John Canning is with the *i*nterdisciplinary Photonics Laboratories (*i*PL) School of Chemistry, The University of Sydney.

Two Great Conferences in November/December 2015

ANZCOP 2015, Adelaide, November 30 - December 3, 2015

Welcome from the Conference Chair

The Australian and New Zealand Conference on Optics and Photonics (ANZCOP) conference series integrates the Australian Conference on Optics, Lasers and Spectroscopy (ACOLS) and the Australian Conference on Optical Fibre Technology (ACOFT). ANZCOP 2015 is the second such conference, and is run under the auspices of the Australian Optical Society and Engineers Australia.

Optics and photonics research continues to be a dynamic and exciting field for research internationally and within Australia. It can be used to ask and answer fundamental questions about quantum mechanics and atomic physics and to probe chemical reactions, to make new types of chemical and environmental sensors, new biological sensors and medical diagnostics and devices, better computers and communications systems, better fundamental standards and metrology, and even to measure elusive ripples in the curvature of space-time.

I warmly invite you to attend ANZCOP 2015 at the University of Adelaide from Monday 30 November to Thursday 3 December. In addition to being the International Year of Light, 2015 is the centenary of Einstein's publication of the field equations for General Relativity and is the year in which the ultra-sensitive Advanced LIGO laser interferometric detectors will re-start the search for gravitational waves. ANZCOP 2015 will include a wide variety of plenary talks, including the Advanced LIGO project and the latest developments in bio-photonics, and a plenary by the 2015 Frew Fellow: Professor Ursula Keller of ETH Zurich.

Come to ANZCOP in 2015. Help us celebrate the IYL and enjoy the exciting science and technology.

Sincerely,
A/Prof Peter Veitch

SPIE Micro+Nano conference, Sydney, 6-9 December 2015

Welcome from the Symposium Chair

In December 2013, the United Nations declared 2015 as the International Year of Light (IYL), recognising the immense importance of light-based technologies in our lives, for our futures, and for the development of humankind.

In December 2015, the SPIE Micro+Nano Materials, Devices, and Applications symposium and the new Australian Institute for Nanoscience (AIN) on the University of Sydney's Camperdown campus will offer the opportunity to celebrate the culmination of the IYL and heightened global awareness of the importance of light-based technologies, including nanoscience.

The symposium is an interdisciplinary forum for collaboration and learning among top researchers in all fields related to nano- and microscale materials and technologies. This event will take place over 4 days, 6-9 December 2015, and will include both oral and poster presentations with a focus on nanostructured and biocompatible materials, medical and biological micro/nanodevices, micro/nanofluidics and optofluidics, nanophotonics for biology and medical applications, plasmonics, solar cell technologies and fabrication.

The University of Sydney has an outstanding global reputation for academic and research excellence. Located close to the heart of Australia's largest and most international city, the Campus features a mixture of iconic gothic-revival buildings and state of the art teaching, research and student support facilities. Sydney is one of the world's most iconic and liveable cities, with plenty of open space, many famous beaches, a glittering harbour, waterways and bushland, great climate and vibrant culture rich of entertainment, cultural activities and sporting events.

We hope to see you in Sydney!

Benjamin J. Eggleton (Chair) and Stefano Palomba (Co-chair)

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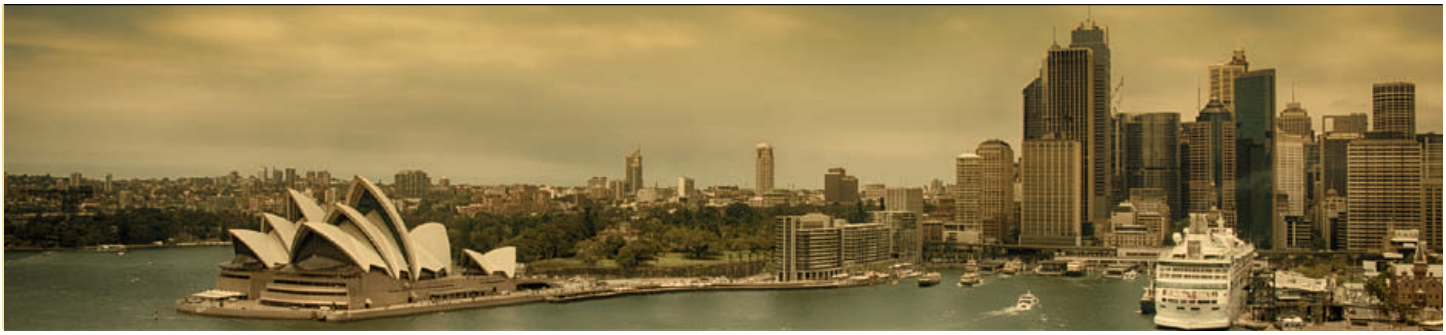

This biennial conference will be a multidisciplinary forum with a focus on research that has enabled promising new materials and applications across many fields, including photonics, energy, security, information, and medicine.

On behalf of SPIE and the symposium organizers, we encourage you to participate in the international symposium on Micro+Nano Materials, Devices, and Applications 2015 in Sydney, Australia. The symposium is an interdisciplinary forum for collaboration and learning among top researchers in all fields related to nano- and microscale materials and technologies. This event will take place over 4 days, 6-9 December 2015, and will include both oral and poster presentations with a focus on nanostructured and biocompatible materials, medical and biological micro/nanodevices, micro/nanofluidics and optofluidics, nanophotonics for biology and medical applications, plasmonics, solar cell technologies, and fabrication.

Due to the interdisciplinary spirit of the event a wide range of topics will be covered. Keynote and invited talks will illustrate leading research activity.

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Micro/Nanofluidics and Optofluidics
- micro/nanofluidic systems
- lab-on-chip devices
- chemical micro/nanofluidic systems
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- quantum plasmonics
- antennas
- nonlinear plasmonics
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- optical integrated systems
- quantum photonics on-chip
- nonlinear photonics on-chip
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- nanophotonics
- biophotonics.

Solar Cell Technologies
- nanophotonics for solar cell applications
- plasmonics for solar cell applications
- biology for solar energy harvesting.

Fabrication
- micro- and nanofabrication methods and techniques
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- nanoimprinting lithography
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Similaritons – What's in a Word?

by John Harvey

The constraint of self-similarity can enable the solution of a number of nonlinear partial differential equations which can be prohibitively difficult to solve by other means. In particular, the search for self-similarity in solutions to the Non Linear Schrödinger Equation has led to the discovery of similaritons of various forms. These are pulses which propagate with constant mathematical form under the influence of dispersion and nonlinearity, and are to be distinguished from first order soliton pulses which are unchirped and propagate with constant shape.

We are all familiar with similar triangles, which exhibit geometric similarity in a particularly simple way, but the concept of similarity, and its exploitation in studying natural phenomena has a wider mathematical application. In Physics, the description of phenomena which develop in a self-similar way, reproducing themselves with the same mathematical form via scaling in one or another dimension, has found application in many different fields. These include plasma physics, hydrodynamics, and some particular problems in optics. Recently however, it has been realised that the techniques used to solve the relevant nonlinear partial differential equations by searching for self-similar solutions, can profitably be applied to various problems in nonlinear optics. My own particular interest and that of our research group in Auckland, has been in the study of nonlinear fibre optic pulse propagation, and this has proved to be a fertile field in which to apply these techniques.

It is important to point out that the study of self-similarity has a long history, and in spite of the value of studying similarity and scaling in general, the power of these techniques has not been as widely appreciated as it could have been. In fact Lord Rayleigh (who made important contributions to the field) commented in 1915 that "I have often been impressed by the scanty attention paid even by original workers in physics to the great principle of similitude" [1].

Much of the study of self-similarity is closely linked to the use of dimensional analysis and scaling laws. Indeed, some of the most striking results can be obtained either by dimensional analysis or by solving the relevant equations governing the behaviour of the system using the mathematical techniques of self-similarity analysis. One of the most famous of these is the analysis of the radius of the blast wave of a high energy (e.g. a nuclear) explosion. In his analysis of this problem, Taylor showed in the 1940s that the blast wave radius (R) expands at a rate proportional to the $1/5^{th}$ power of the energy released and the $2/5^{th}$ power of the time after the explosion [2,3]. Plotting $R^{5/2}$ against time using declassified images of a nuclear explosion, enabled him to determine the yield of the explosion, which at that time was a closely kept secret!

As mentioned earlier, self-similar effects have recently risen to prominence in the area of nonlinear fibre optic pulse propagation, where the development of pulses which propagate self-similarly arise naturally in high power fibre amplifiers. The propagation of pulses in a single mode optical fibre, under the combined influence of gain, dispersion and nonlinearity is governed by the Non Linear Schrödinger Equation (NLSE) which is a remarkably good description of pulse propagation which works well down to pulse durations of about 300fs in single mode fibres. This equation has the form:

$$\frac{\partial \psi}{\partial z} = -i\frac{\beta_2}{2}\frac{\partial^2 \psi}{\partial T^2} + i\gamma(z)|\psi|^2\psi + \frac{g(z)}{2}\psi$$

where β_2, γ and $g(z)$ characterise the dispersion, nonlinearity and gain of the fibre respectively. This equation has been widely used in studying high speed optical communications systems, and the generation and propagation of high power pulses for materials processing. In the telecommunications bands, standard optical fibres made of fused silica have anomalous dispersion, and these fibres can support the propagation of optical solitons, which are a particular type of exact solution of the NLSE. In the normal dispersion regime, soliton propagation is not possible (unless we include dark solitons which are not of any significance for communications or material processing applications). In general, in this regime, the combined effects of dispersion and nonlinearity tend to cause a pulse to spread, in contrast to the anomalous dispersion regime where the two effects can balance each other for a particular pulse energy to generate a soliton. The problem with high power pulse generation in single mode fibres in both normal and anomalous dispersion fibres however, was that the pulses were subject to pulse distortion, pulse break up and a phenomenon known as optical wave breaking.

In 1993 Anderson et al. had published an interesting paper showing that these pulse distortions could be avoided in the normal dispersion regime, for a pulse having a parabolic intensity profile which would propagate self-similarly [4]. Self-similar propagation of a parabolic shaped pulse under the combined influence of dispersion and nonlinearity can readily be understood, since the instantaneous frequency shift generated by self-phase modulation is proportional to the derivative of the intensity. Consequently even an unchirped parabolic pulse would immediately acquire a linear chirp when propagating, since the derivative of the pulse shape is linear. A chirped parabolic pulse will simply have its chirp slope modified by SPM. The effect of the dispersion term in the absence of nonlinearity, is simply to spread out a linearly chirped pulse whilst preserving its shape, since the different frequency components have different group velocities, so it is not surprising that a parabolic pulse will propagate self-similarly under the combined action of SPM and dispersion. Anderson et al. not only proved this result in the limit of high intensity pulses, but also derived estimates of the potential compressed pulse duration obtainable by compensating the chirp of the parabolic pulse.

Parabolic pulses remained of little interest however, since they had never been observed and it was unclear how to produce them. The situation changed dramatically in 2000 however, when Vladimir Kruglov joined our group, and

was able to show that the parabolic pulse was an asymptotic self-similar solution to the NLSE with gain, for any input pulse shape. This meant that any pulse would evolve to a linearly chirped parabolic shaped pulse given sufficient propagation distance and gain (see Figure 1). The first experimental demonstration of the development of parabolic pulses by this means, was enabled by our collaboration with Martin Fermann at IMRA. In these experiments we were able to combine our newly developed FROG instrumentation for completely analysing the amplitude and phase of a pulse, with his experiments on propagating initially short pulses through a high gain amplifier, which generated the asymptotic form after a few metres of fibre amplification [5]. The analysis of the pulses showed unequivocally that they had a parabolic shape and linear chirp, even though the input pulses were approximately Gaussian in shape with minimal chirp.

Parabolic pulses may seem paradoxical initially, since they have compact support, and outside the region of the pulse there is no intensity at all. This seems counter intuitive, but in the real world, the generation of parabolic self-similar pulse shapes is asymptotic (i.e. $z \to \infty$) and for finite distances the pulse does have "tails" which can be derived as intermediate asymptotics, and these tails become weaker and weaker as the parabolic pulse grows and spreads self-similarly (see Figure 1). The pulse compression obtainable using a standard dispersion compensation system for the Yb doped fibre amplified pulses is impressive, leading typically to ~ 100fs duration pulses.

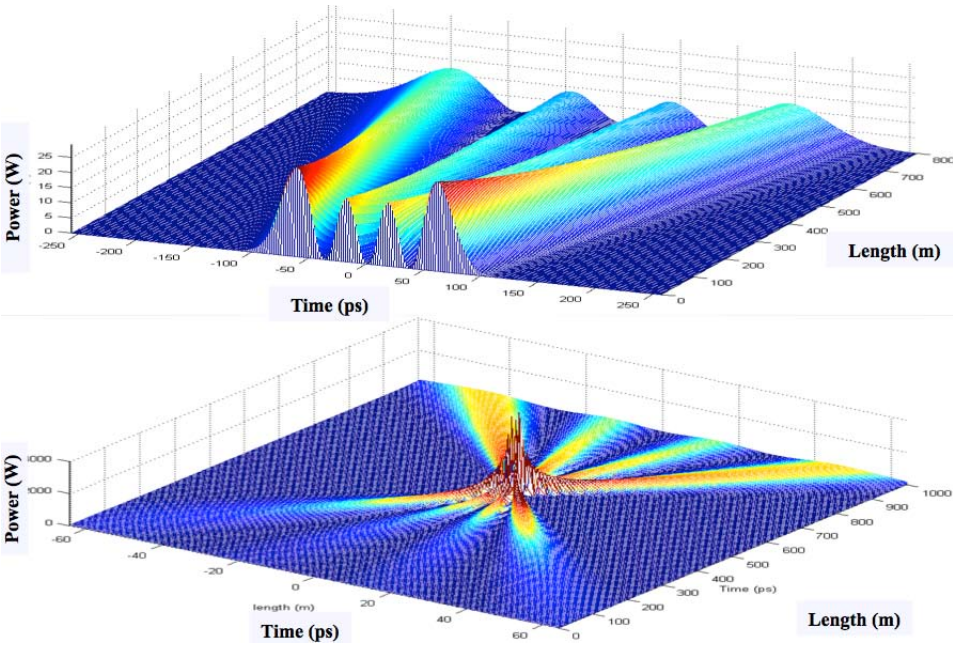

Figure 2. Linear evolution of a complex pulse with four peaks and a linear chirp in the case of dispersive broadening (top panel) and dispersive compression (bottom panel). The pulse remains self-similar except in the region of maximum compression.

Despite the importance of the parabolic pulse, there are a number of other pulse shapes that can propagate self-similarly in an optical fibre. These pulses have come to be known as "similaritons". This word was invented by John Dudley and myself over a beer in 2000 and used in a publication on self-similar propagation that year [6]. We were not sure at the time if the word would catch on, but a recent Google search generated 9620 results so it seems have done so! In collaboration with Vladimir Kruglov and others, we have developed a number of other similariton solutions of the NLSE and its linear counterpart, and two of these deserve special mention.

Firstly it is useful to be aware of the fact that when nonlinearity can be neglected ANY pulse will evolve self-similarly except in one particular region. The region where the pulse loses its similariton character is where an initially chirped pulse has its chirp compensated by the dispersion of the fibre, leading to a focussing in time and a minimum pulse duration, with a very different shape in the focal region. This change in pulse shape at the point of minimum duration occurs for nearly all pulse shapes, with the notable exception of the chirped Gaussian pulse. This pulse remains Gaussian in shape at the focal point, and propagates self-similarly over all spatial regions [7]. It is important to note that the self-similar character of the propagation is recovered after the focal region (albeit with a reversal of the sign of the chirp). A somewhat artificial example which illustrates these characteristics well, is shown in Figure 2. This shows the evolution of complex pulse shape with four peaks and a linear chirp through the region of minimum duration.

As an example of the application of this result for self-similar propagation under the influence of dispersion, it predicts that an unchirped hyperbolic secant pulse will propagate self-similarly in an optical fibre under most experimental conditions. This result is important as there is no analogue to the exact result for a Gaussian pulse shape applying to the hyperbolic secant shape, and this situation is exactly what happens experimentally, when an attenuated soliton pulse is propagated under the influence of dispersion only.

Secondly, in the case of propagation in the anomalous dispersion region, the application of self-similarity techniques (which search for a solution with a linear chirp), leads to a linearly chirped hyperbolic secant solution of the NLSE for a particular spatial distribution of gain, nonlinearity and/or dispersion [8]. This exact solution

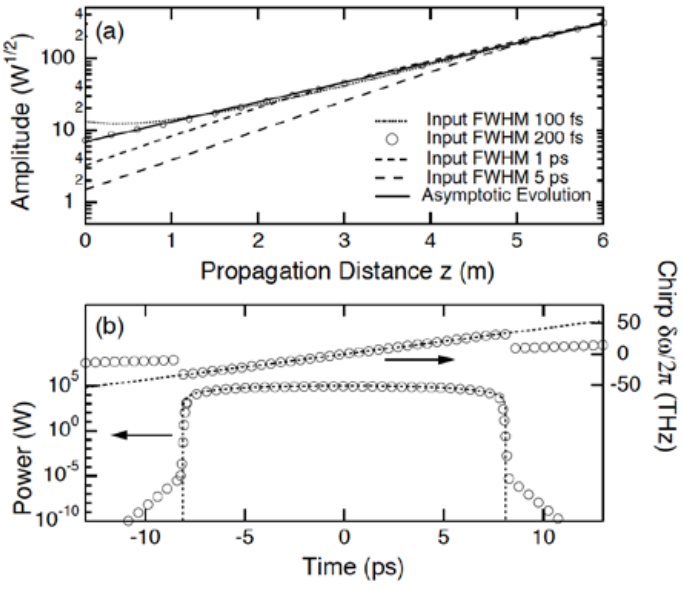

Figure 1. Evolution of an arbitrary input pulse to the parabolic form. The final form (lower panel) is independent of the input pulse shape, and depends only on the pulse energy. The upper panel shows the evolution of different duration input pulses of the same total energy, while the lower panel displays a logarithmic plot of the power and a linear plot of the chirp of the pulse form developed in numerical simulations (circles) compared with the pure parabolic shape (dotted curve).

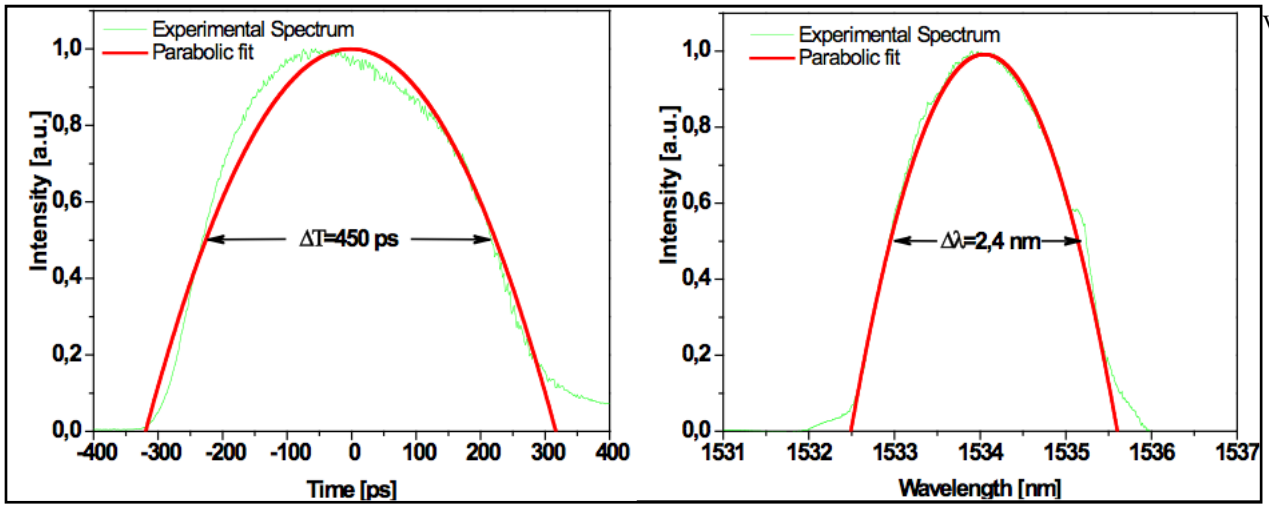

Figure 3. Output of a Raman similariton laser producing parabolic shaped pulses. The spectrum and the time profile of the pulses are both parabolic [12].

continually compresses whilst its shape is maintained and its chirp steadily increases. This result can also be obtained by using the inverse scattering technique which is the standard approach for developing the soliton solution, and consequently these pulses have also been called "chirped solitons". The search for self-similar solutions however, is a substantially simpler way to obtain the same result. In a series of experiments we have demonstrated the existence, and studied the propagation of these pulses using a dispersion decreasing fibre [9].

It is also appropriate to mention the development of similariton lasers where the parabolic pulse shape develops within the laser cavity. The challenge in these lasers is to develop a means of reconstructing the seed pulse for amplification from the parabolic similariton which has a much broader spectrum and duration. This problem has been overcome by various different groups however, [10-12] and Figure 3 shows the output of a Raman gain mediated similariton laser developed in our laboratory. This laser has the characteristic parabolic shape in both the time and spectral domains.

Finally I would encourage anybody working with high energy fibre amplifiers to become familiar with the results obtainable by self-similar analysis. The wide availability of computers and propagation code based on the split step Fourier method, has made the simulation of pulse propagation widely available to all. However, the result of an individual pulse propagation simulation, does not tell us very much about the physical mechanism underlying the propagation. The understanding generated by analytical results such as those obtainable by similarity analysis, is significantly greater than that obtained by even extensive numerical simulations. Furthermore, since the NLSE also has application in Bose Einstein condensates, these techniques and results (in particular those on parabolic solutions) have application in this area as well.

For further reading on parabolic similaritons, and their adoption in various photonic applications see the review article by John Dudley et al. [13], while the book by Barenblatt [14] which contains many applications of self-similar analysis in other areas, is strongly recommended.

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John Harvey is now fully occupied running Southern Photonics Ltd which he set up as a spin-off company from the University of Auckland in 2001. He also has a fractional appointment as a Professor at the University of Auckland managing the industry engagement arm of the Dodd Walls Centre for Photonic and Quantum Technologies.

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Confirmed speakers include astronomer **Joss Bland-Hawthorn**, quantum theorist **Andrew Doherty**, biologist **Min Chen** and optical researchers **Ben Eggleton** and **Martijn de Sterke**, all Professors at the University of Sydney. Presentations will appeal to a wide audience and will last 40 minutes, with ample question time allowed.

For further information visit our webpage at http://www.cudos.org.au/nobelprizesForLight

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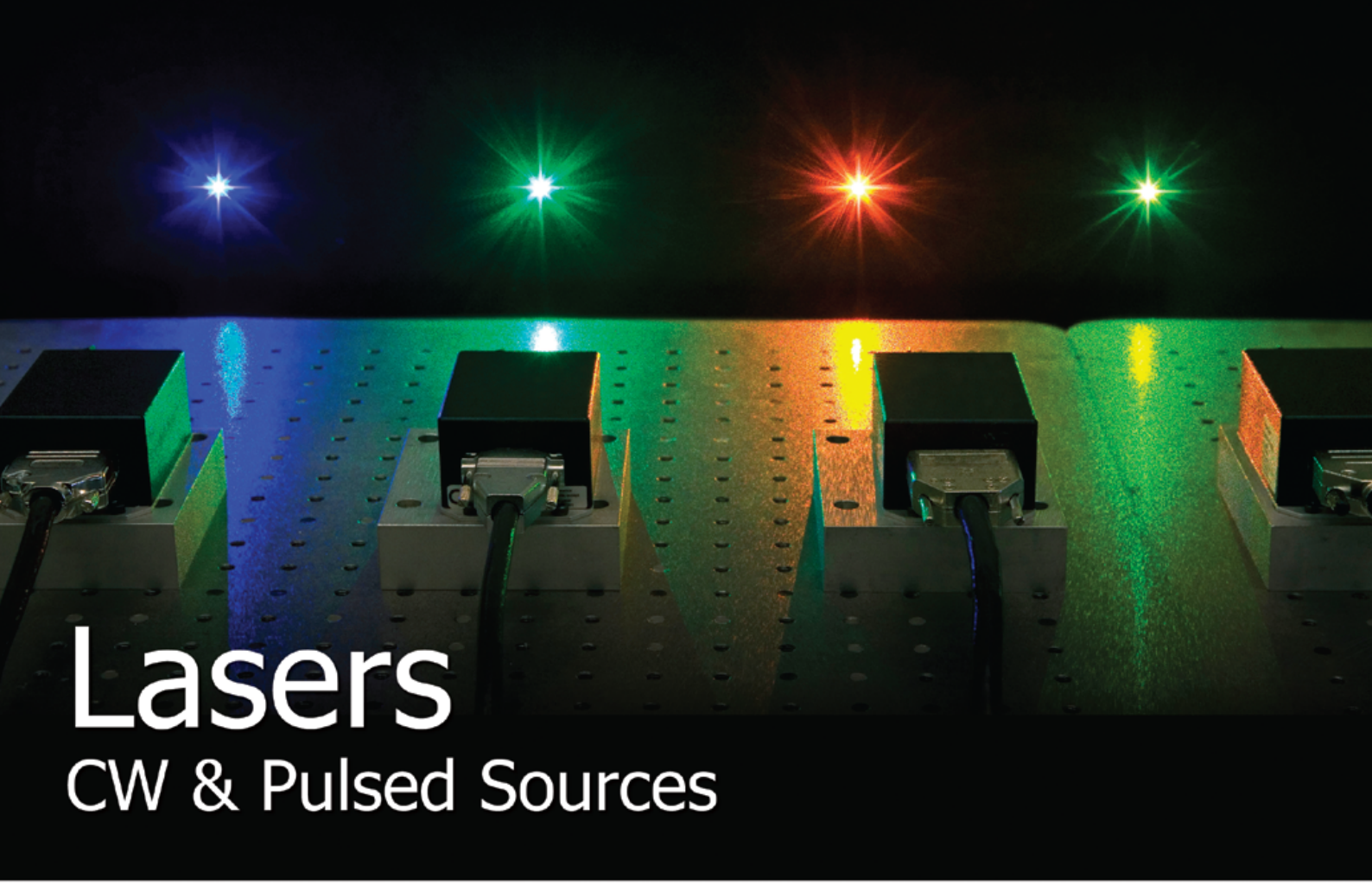

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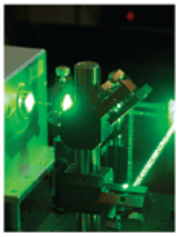

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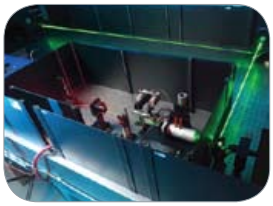

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Optics in Everyday Life: What Colour are Electrons?

I won an argument once at a lively cocktail party on the question of: what colour are electrons? Most people in the group opted for either red or blue, as represented in most popular diagrams but unsupported by any reasonable evidence.

by Tony Klein

My winning entry was that electrons are silvery in colour, on the grounds that when we look at metals, what we really see is the light scattered by the free electrons. Can't argue with that! Classically, free electrons are "shaken" by the electric field of the incident light and re-radiate it unchanged in colour. Quantum mechanically it's the same story, regarding elastically scattered photons, provided that there is no absorption.

Whoa! What about gold, copper etc? What is responsible for the yellow, red etc. colours of these metals? More detailed answers about the colour of metals involves solid state physics, rather than optics and depends on the band structure of the metals in question.

For the less "silvery" and greyer metals, such as iron, clearly some absorption, i.e. energy loss, or inelastic scattering is responsible for the less complete reflection. This is caused by photons being absorbed by electrons lying deeper below the Fermi surface. This, in turn, depends on the so-called "density of states", i.e. the distribution of electrons as a function of energy below the surface of the conduction band. All incident photon energies are still reflected but some are absorbed, creating phonons and eventually heat.

In gold, copper, etc, a very high density of electron states lie in the (full) 3-d valence band, below the (half-full) 4-s conduction band (see Figure 1) and only sufficiently energetic electrons are absorbed so that the lesser energy ones - i.e. the longer wavelength ones, corresponding to energies below 2.3 eV, the yellow and red ones, are re-radiated.

This causes the characteristic colours of these metals and alloys because their reflectances are wavelength-dependent as shown in Figure 2.

This, in turn, is explained by the detailed band structure of the metals concerned, as explained in Reference 1, from which these diagram are borrowed. Note that even for silver, absorption sets in at a shorter wavelength, corresponding to ultraviolet photons of energy greater than 4 eV.

The same article [1] goes on to explain the changes in colour exhibited by gold nano-particles, depending on their size, a subject beautifully illustrated by our Melbourne colleague, Professor Paul Mulvaney - see Figure 3.

There is just one other possibility: Maybe electrons are black, i.e. the colour of coal, whose electrons absorb all incident photons, of whatever colour. So, why is coal black? The standard explanation is to do with the band structure of graphite, which leads to the absorption of photons of all energies in the infrared and visible regions.

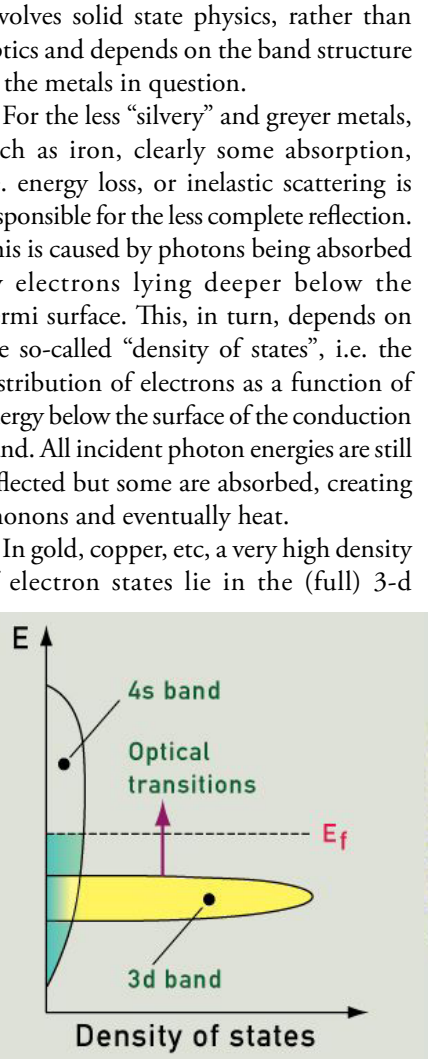

Figure 1. Band structure of Gold. Credit: WebExhibits [1].

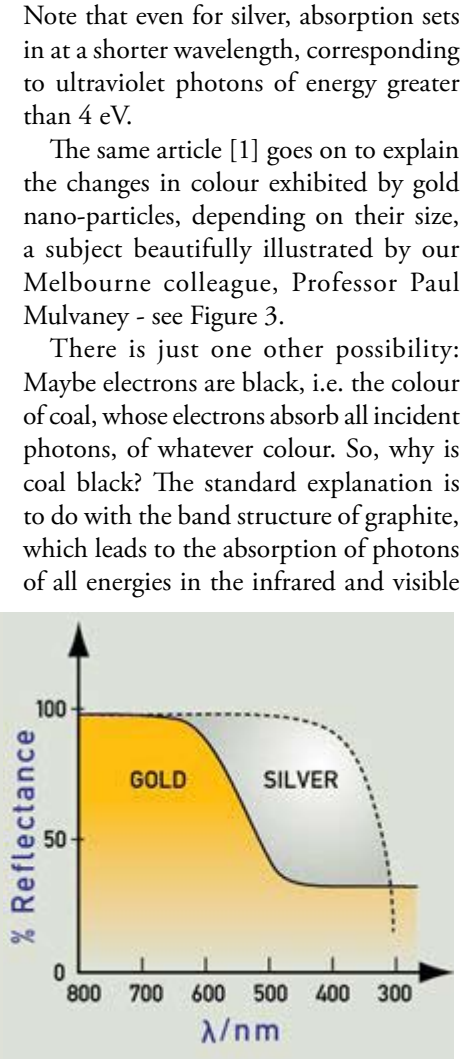

Figure 2. Reflectance of gold and silver. Credit: WebExhibits [1].

Figure 3. The diameter of gold nanoparticles determines the wavelengths of light absorbed. The colors in this diagram illustrate this effect. Credit: Paul Mulvaney.

As we know, graphite consists of layers of 2-dimensional graphene, which absorbs photons across the entire visible and near infrared ranges, having a nearly wavelength-independent transmission of $1-\pi\alpha$ per layer, where $\alpha=1/137$ is the fine structure constant. The rest of the photons are absorbed and none are reflected, making graphite black, if sufficiently thick. The derivation is quite simple and is given in Reference 2.

However, I still prefer my original answer: electrons are silvery. Do you agree?

References

[1] Douma M, curator. (2008). *Gold.* In 'Causes of Color'. http://www.webexhibits.org/causesofcolor/9.html

[2] Kravets V et al., *Spectroscopic ellipsometry of graphene and an exciton-shifted van Hove peak in absorption.* Phys Rev B. April **81**(15) 2010. http://arxiv.org/ftp/arxiv/papers/1003/1003.2618.pdf

Emeritus Professor Tony Klein is a Foundation Member and Past President of the AOS. Tony is with the School of Physics, University of Melbourne.

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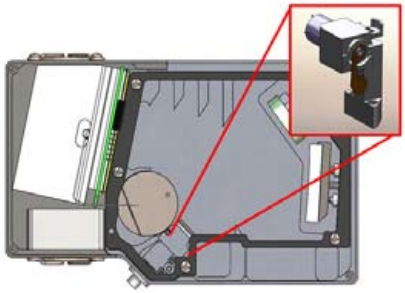
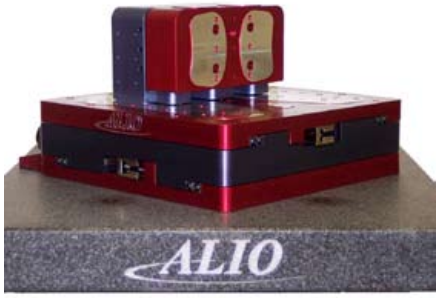
QE Pro Internal Shutter Adds Convenience

The internal shutter is now available for the QE Pro for more effectively managing dark measurements. The new optional feature is useful for applications where light intensities change, requiring users to dynamically adjust integration times and renormalize the spectrometer.

The QE Pro internal shutter removes the need for an external shutter, which improves signal throughput in the setup and allows for shorter integration times for an equivalent level of signal.



Lastek appointed exclusive distributor for Alio Industries nano technology and precision motion systems



Lastek has been appointed exclusive distributor for Australia and New Zealand for Alio Industries, the Colorado-based manufacturer of nano technology and precision motion systems.

Alio Industries began in 2001 with an idea to create "a better way" to meet the nano-precision robotic needs. This initial idea has grown into an ever-expanding product line that includes Hexapod robotic systems, air bearing systems and mechanical bearing linear and rotary nano-precision systems for atmospheric, clean room and ultra-high vacuum chambers all with TRUE NANO Positioning™. Industries served include semiconductor, biomedical, ink jet deposition, lithography, nano/micro machining, metrology & synchrotron.

ALIO, (which is Latin for "A better way") is an innovator in nano technology motion systems. ALIO's designs exceed current standards of precision product designs for automation technology. Holding two patents for the Parallel 6 Axis Hexapod and the Parallel 3 Axis Tripod as well as several patents pending for nano Z stages and planar air bearing systems, ALIO has set the pace for nano-precision design and systems.

ALIO's linear and rotary stage lines were designed to be cost effective and complement the market demand for high quality, nano-precision motion. These applications can be used in normal atmospheric environments, clean rooms, and vacuum chamber environments. ALIO's design of the rotary stages can be utilized for stand-alone motion or stackable for various serial kinematic structures.

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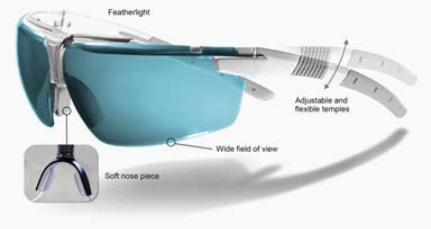
Laservision USA Introduces F29 Laser Safety Eyewear

Wearing ergonomic laser safety eyewear reduces a person's stress and increases productivity in the R&D laser environment. Laservision USA's new F29 laser safety eyewear has been created for that purpose. This frame is lightweight, pressure-free, adjustable, and offers a wide field of view.

F29 eyewear is available in these polycarbonate laser safety filters - P1M01 for UV, IR, and CO2 lasers and P5H01 for UV, IR, and Diode lasers. More filter options will be available soon.

F29 Laser Safety Eyewear features:



- **Featherlight construction** - this eyewear can be worn comfortably for extended periods of time
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APPLICATIONS:

The UV-KUB 1 and 2 systems are ideal for a wide range of applications in laboratories and R&D groups dealing with optics, biotechnology, microtechnology, photolithographic processes requiring 1 or 2 masking levels, wafer bonding, simple layer or adhesive curing, connections, assemblies and biological or cell cultures.

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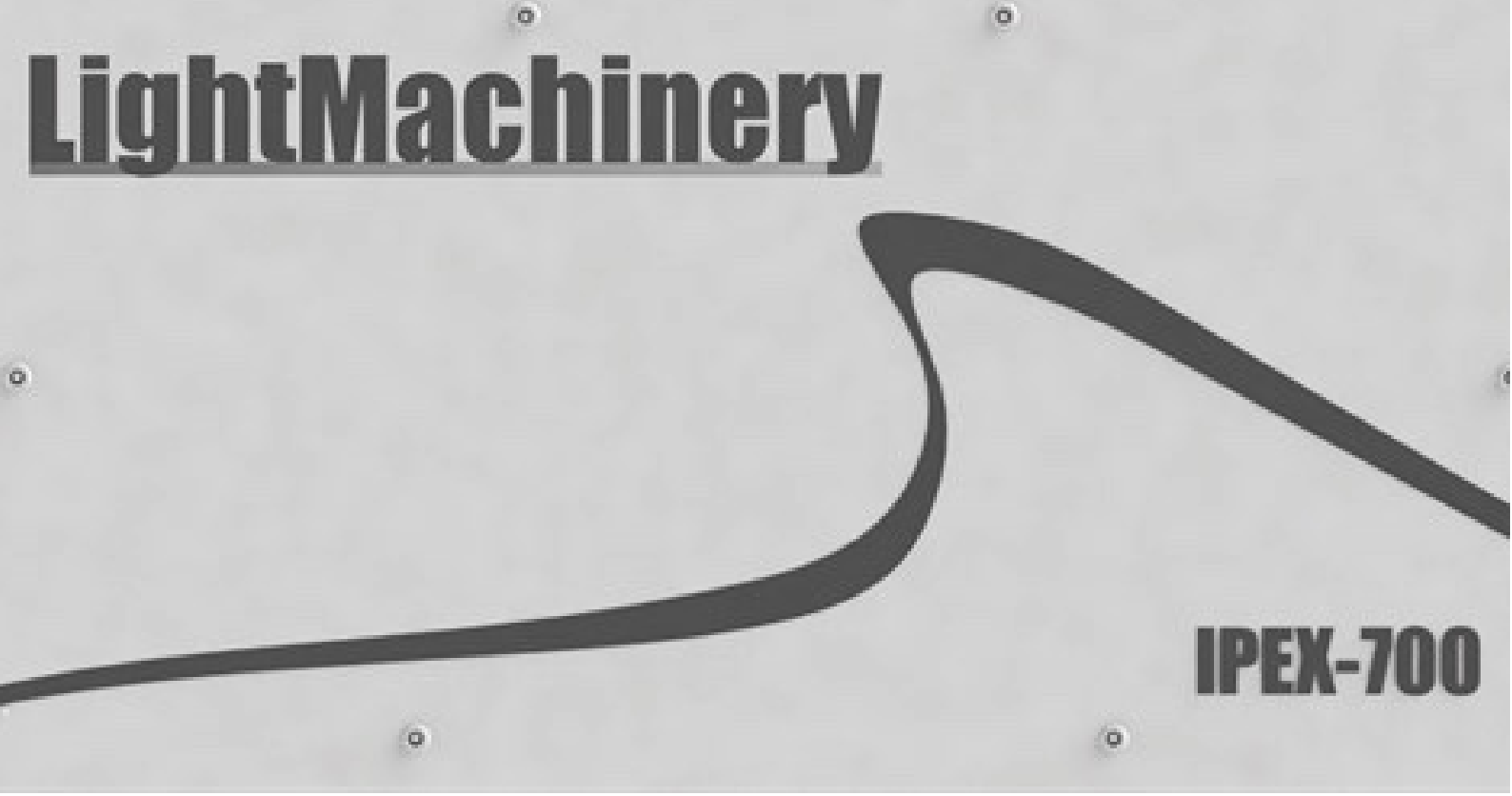

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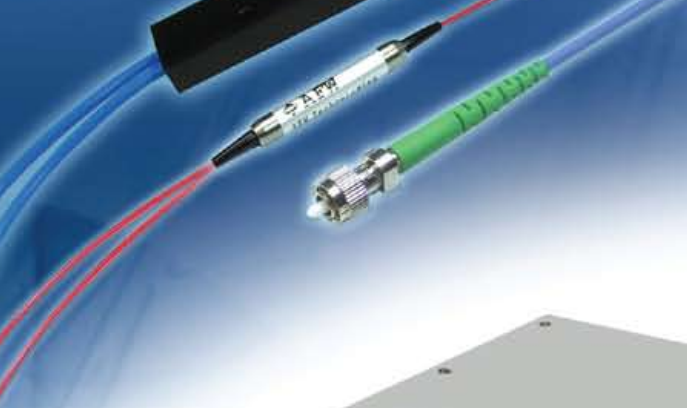

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