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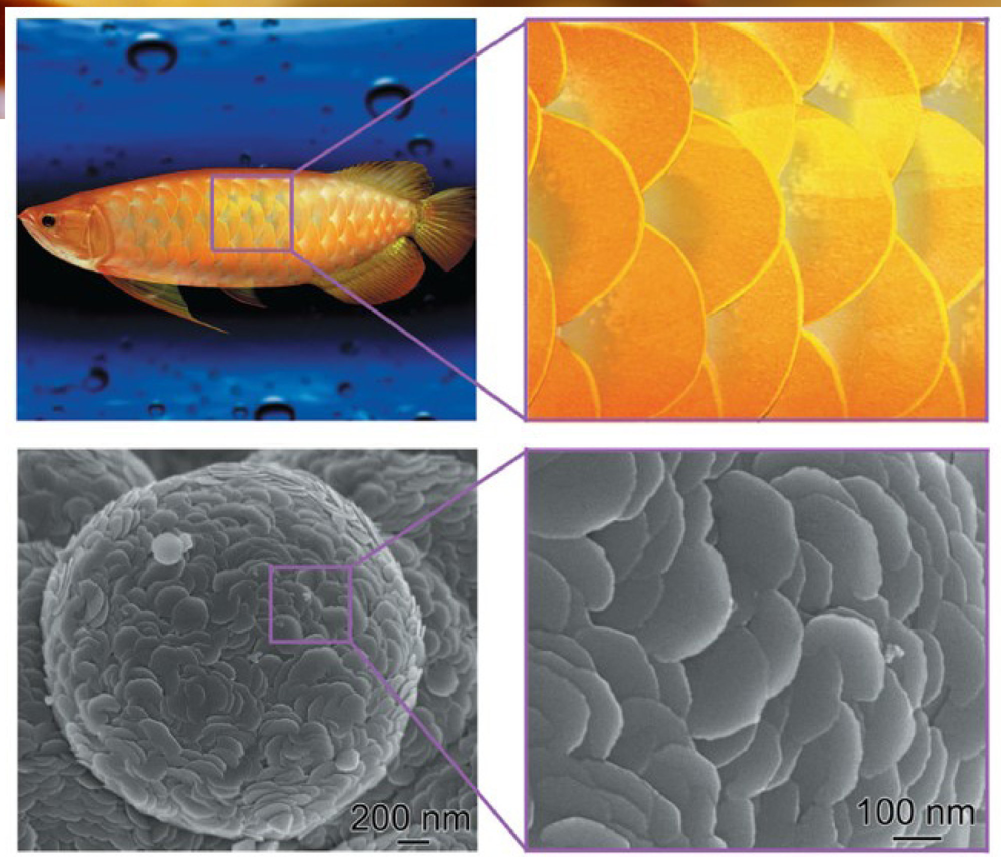
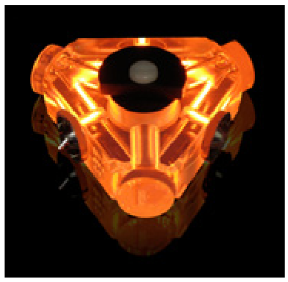


AUSTRALIAN OPTICAL SOCIETY



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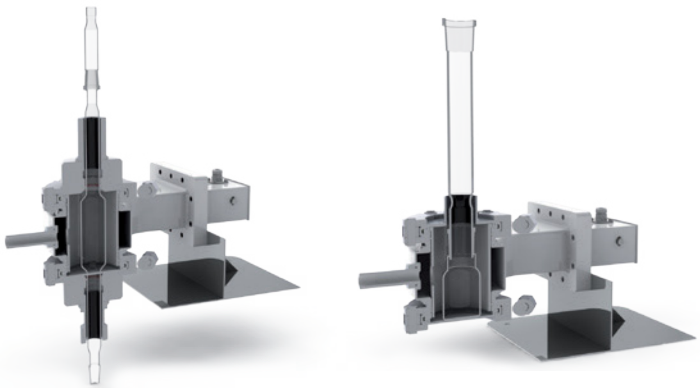

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APPLICATIONS

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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.

Call for submissions!

Please consider writing something for the next issue.
We are looking for:

Scientific articles on any aspect of optics

Review articles on work in your lab

Conference reports from meetings you attend

Articles for the Optics in Everday Life section

General interest articles

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
- General Interest Article: Any item of interest to members such as reports on community engagement, science in society, etc.
- Article for Optics in Everyday Life section: An explanation of the optics behind any interesting effect, phenomenon, or device.
- News Item
- Obituary
- Book Review
- Cartoon or drawing
- Crossword or puzzle

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:

- Bio-inspired photonic nanomaterials lead to some amazing possibilities. Horse-fly eyes (large image, credit Thomas Shahan) are compound with microstructured surfaces (shown inset) that give a wide field of view and high photosensitivity. Inset is an example of microspheres with nanolenses inspired by this structure.

  Asian Arowana fish have scales that allow camouflage protection (upper central images) that have also inspired nanostructures with useful optical properties (lower central images), see page 34.
- Insets (left to right)
  - Tony Klein received the 2016 AOS WH (Beattie) Steel Medal in March, see page 9.
  - The history of ring lasers and how they contribute to gyroscopes and navigation systems is examined in our Optics in Everyday Life section, see page 30.

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 AOS council. 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 welcome, and should contact the editor.
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Copy Deadline
Articles for the next issue (June 2017) should be with the editor no later than 22 May 2017, advertising deadline 15 May 2017.

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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

It seems only a few weeks have passed since I wrote the last President's report. A lot has happened in the world since then, and there is great concern about the impact that one of the big events will have on science - I mean of course the outcome of the US Presidential election, and especially the Executive Order effectively implementing a selective ban on entry to the USA. With the potential impact on science in general, and on specific scientists including potentially AOS members, there was significant discussion on the AOS Council about this, and what our response should be. There was plenty of support for us making a statement expressing our concern. However, for now we have opted to pass on the statements of the US and international societies, discuss a coordinated response with other Australian societies, and seek information from our membership of anyone affected.

The AOS Council has chosen not to make a statement, mainly because for us to engage in politics we need to be sure that it is aligned with the society's objects around spreading, sharing and advancing knowledge in optics (see AOS Constitution 2.1). However, at a personal level I encourage all members, whatever your political persuasion, to engage with politics and politicians. It is critical that rational views and scientific knowledge are at the heart of decision making in our societies. I will try to make a small contribution to this when, with AOS councillor Daniel Gomez, I attend the Science Meets Parliament event in March.

I was delighted just now to pay my AOS membership online through our own website. I usually use the joint arrangement with OSA. However, before commending the new arrangement to you, I wanted to test drive it. AOS treasurer Baohua Jia has succeeded where several of us (myself included) failed in the past - the days of having to fax your credit card details are rightly consigned to history. Please do let colleagues know that we have joined the modern world, because I do know some people allowed their membership to lapse due to the difficulty of paying us.

As well as Baohua's hard work, this step forward has been enabled by the transfer of our website to a new host over the last couple of years. The core functions are all running, and there is a great opportunity to do more with it. This includes, of course, keeping the content up to date. However there is a lot more we can do with it to provide value to you, our membership. We are looking for someone with the interest, ability and a little time, to support and develop our internet presence. If you are interested and want to discuss this, please email me.

Over the last few weeks there has been good progress on several events that the AOS runs or sponsors. We are pleased to be sponsors of a series of Imaging and Optical Physics seminars running in Victorian universities. This seems like an excellent initiative to bring together the optics community in members across the several universities. Planning for KOALA and ANZCOP at the end of 2017 are progressing well.

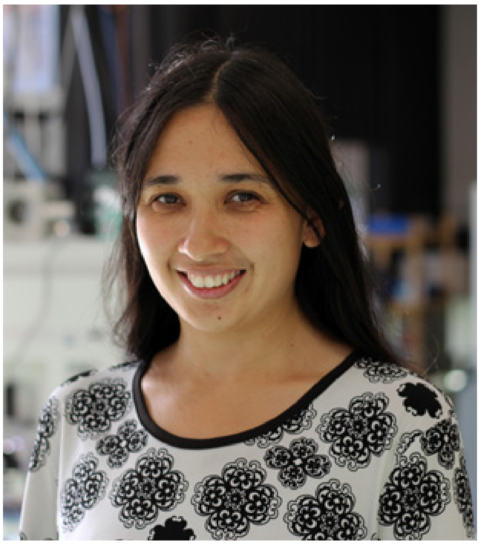
AOS is a regular sponsor of KOALA, the Conference on Optics, Atoms and Laser Applications, run by the students in the OSA student network. KOALA is scheduled for the last week of November in Queensland.

Shortly after this, in the first week of December, ANZCOP will be held in Queenstown, New Zealand. ANZCOP, the Australian and New Zealand Conference on Optics and Photonics conference, integrates two of the AOS conferences: ACOLS and ACOFT. This is the first time in forty years that ACOFT will be held outside Australia, and Queenstown should be a hugely popular location. AOS councillors John Harvey and Frederique Vanholsbeeck along with the Director of the Dodd-Walls Centre (David Hutchinson) are leading the team organising ANZCOP 2017.

With these events we are, of course, seeking to implement the provisions of the Equity and Diversity Policy we passed late last year. Feedback from members on how we are doing, and how we can improve, is always welcome.

Simon Fleming
AOS president

Editor's Intro



Welcome to the first issue of AOS News for 2017. Apologies for the delay in this issue reaching you - hopefully the June issue will be hot on its heels. We have a range of articles, with a report on the 2016 AOS WH Beattie Steel Medal presentation to Tony Klein as well as news of a new initiative looking to increase female engagement in science. There is an item about imaging low earth-orbit satellites as well as a report on bio-inspired photonic nanomaterials and the exciting possibilities these bring. Our 'Optics in Everyday Life' section looks at the history of ring lasers. 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 National Science Statement was recently released by the Minister for Industry, Innovation and Science, Arthur Sinodinos (www.science.gov.au/SCIENCEGOV/NationalScienceStatement/index.html). This is part the process of forming the 2030 Strategic Plan for science being developed this year by Innovation and Science Australia, providing direction until 2030. The statement does highlight many promising aspects including the needs for basic research and long-term sustainability as well as increasing community awareness and engagement.

The Australian Academy of Science welcomed the statement, saying, "The Academy acknowledges the Government's leadership to address inequality in science education, participation and employment, particularly through support of the Science in Australia Gender Equity pilot. The Statement recognises the role of science in our society and economy. It highlights that new knowledge is the fuel that drives innovation and that support is required from basic to applied research. The Statement provides much needed long-term direction and purpose for government activities in regards to science and shows an understanding of the needs and realities of the sector. The Academy is ready to work with government to shape an investment strategy that supports this plan. It offers a comprehensive framework, and a guide to decision-making and investment. The focus areas point to a solid foundation for science, including infrastructure, education, engagement, and collaboration mechanisms -all important elements to create a strong science and innovation sector. The document builds on the National Innovation and Science Agenda and recognises science's role in driving Australia's economic and social wellbeing."

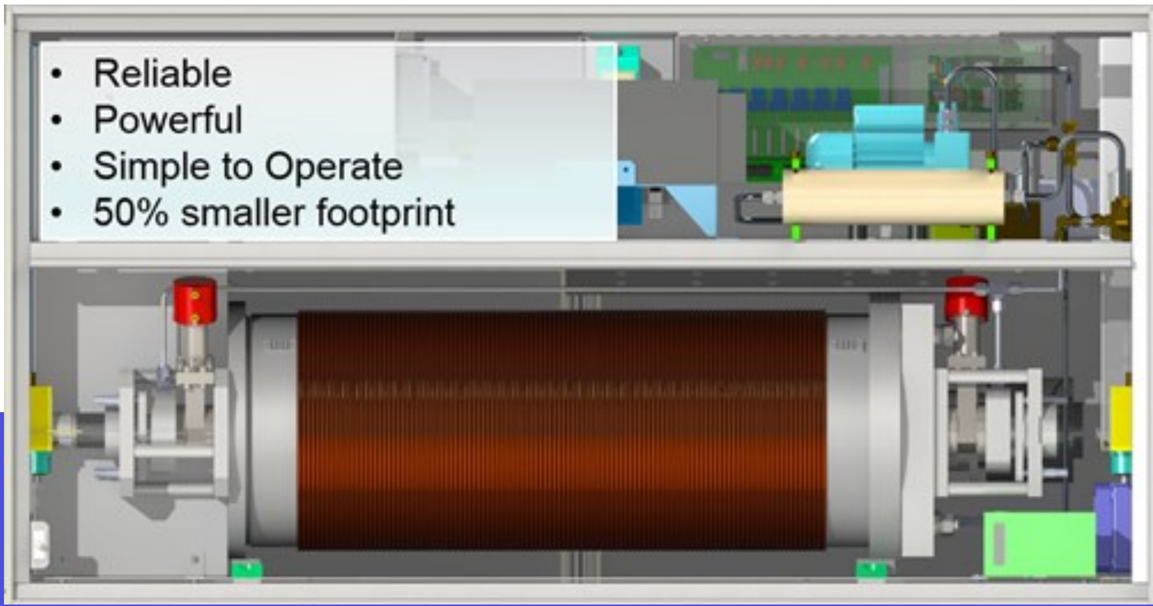
Ken Baldwin, AOS Councillor, Director of the Energy Change Institute and Deputy Director of the Research School of Physics and Engineering at the Australian National University said, "The National Science Statement contains no significant new strategies or funding announcements, but does affirm the Government's strong support for science as a driver of the economy and social advancement. We eagerly await the 2030 Strategic Plan being prepared by Innovation and Science Australia (ISA) that will be released later this year. The expectations of the science community will be riding on this document, which needs to place Australia at the forefront of R&D performance - both in the government and private sector. What is needed from the Government are incentives for industry to collaborate more broadly in research, and for support to be provided more generally to enable Australian researchers (whether private or government supported) to link with and leverage research overseas."

The expert reaction collated by the Science Media Centre (www.scimex.org/newsfeed/expert-reaction-national-science-strategy-released) was generally positive as it is encouraging to see that the government appreciates the need to support science and have actual planning in place. There was some concern about any actual changes that may take place, particularly with the current low levels of public science funding as it is much easier to produce a statement of well-intentioned objectives than to have policy changes to provide solutions to the issues raised. There was also concern about the influence of political ideology that has been seen in science provision as well as the need for bipartisan support so that long-term changes can actually be implemented and maintained. The vision to engage Australians with science, build scientific capability and skills, produce new research and improve and enrich lives through science and research is promising. It just remains to be seen how this can happen and what the government will suggest to achieve this.

I hope you enjoy this issue of AOS News,

Jessica Kvansakul
Editor

There is a better excimer laser.



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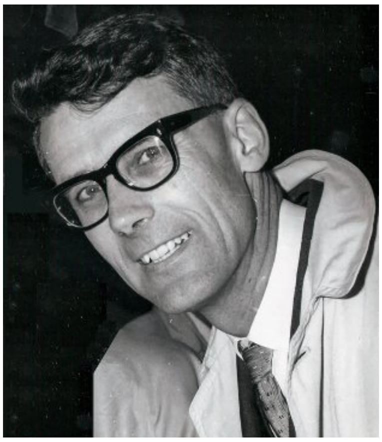
The 2016 AOS WH Beattie Steel Medal Presentation

by Jessica Kvansakul

The 2016 AOS WH (Beattie) Steel Medal for an outstanding contribution to optics in Australia was awarded to Tony Klein. Tony gave a lecture on his work and received the medal in March at the University of Melbourne.



WH (Beattie) Steel (1920-2002).

Beattie Steel was one of Australia's most distinguished Optical Physicists and the Inaugural President of the Australian Optical Society.

Born in 1920, he was educated at Geelong Grammar where he was Dux, excelling in Physics and Maths and participating in the School Play, Shakespeare's "Much Ado about Nothing", playing the role of Beatrice, thereby acquiring the nickname "Beattie" which stuck for the rest of his life.

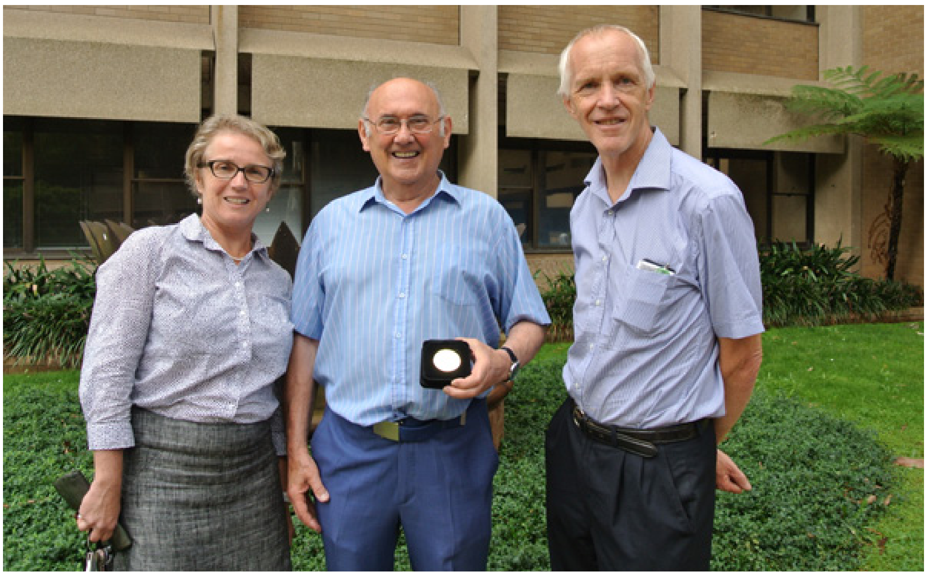
He did a BSc (1st Cl. Hons) in the School of Physics at Melbourne University and went to do some war-related work in Sydney. After the war he won a scholarship to do a PhD in Cambridge, in the Astrophysics Department where he told them that he was interested in Optics. They told him that Optics is "a French Science" so he went to the Sorbonne where he completed his Doctorate. Upon returning to Australia he got a job at the CSIRO National Measurement Lab - where he became the "doyen" of Australian Optics, imported Fourier Optics into Australia, wrote "THE" book on interferometry and so forth.

Beattie was instrumental in starting the AOS and the prize awarded in his name, the WH (Beattie) Steel Medal is the most prestigious award of the AOS. For a full list of previous winners and more information on the start of the society see the AOS website (optics.org.au).

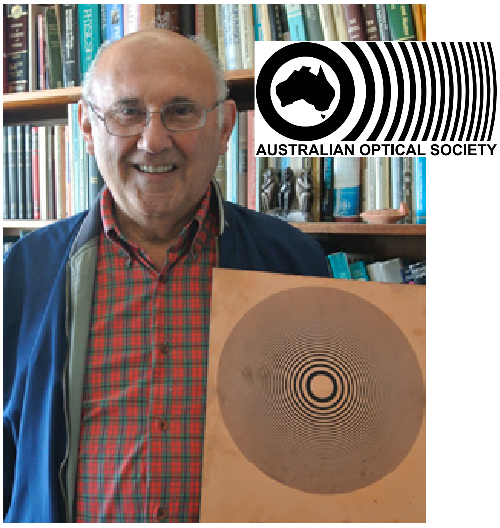
Tony Klein was also part of the early leadership of the AOS, being a foundation member and past president of the society. He was presented the 2016 award in March this year and gave a lecture on his work entitled 'A Neutron is a Particle is a Wave'.

During the lecture Tony told the audience all about neutron optics. The talk detailed his collaboration with the late Geoff Opat and trips to Grenoble that formed the basis of a lot of his most famous work. This included performing the 'ultimate' Fresnel diffraction experiment with neutrons using a 2mm diameter zone plate made at the Telecom research labs in Clayton (later known as the Telstra research labs that closed in 2006) as a lens for 2nm neutrons. After the Fresnel diffraction experiments Tony and Geoff worked with professor Sam Werner at the University of Missouri (Columbia) on further neutron optics experiments from 1980 onwards, including neutron interferometry using a perfect silicon crystal interferometer.

Tony also recounted how the AOS logo was devised during a meeting of AOS foundation members in his office. The pattern is cut from the zone plate plotted at the Telecom research labs that he used in his work.



AOS representatives former president Ann Roberts (left) and past president Stephen Collins (right) with Tony Klein after receiving the award.



Tony with the zone plate that was inspiration for the AOS logo (inset).

Acknowledgements
Thanks to Tony Klein for providing all the background information on Beattie and his useful suggestions on the article.

Jessica Kvansakul is editor of AOS News and is with La Trobe University, Melbourne.

The Hunt for the Superstars of STEM to Engage More Women in Science

by Lisa Harvey-Smith

This article was originally published on THE CONVERSATION

Superstars of STEM is a new program by Science and Technology Australia that aims to smash the stereotypical portrait of people in science, technology, engineering and mathematics (STEM).

The plan is to identify 30 superstar women currently in STEM, and work with them to create role models for young women and girls, and thus move towards equal representation in the media of men and women in STEM.

As the new ambassador and a mentor for Superstars of STEM, my role is to encourage broad participation, which we hope will elevate the visibility of women STEM professionals in public life.

Encouraging more women in STEM

There are already some programs that support female scientists and technologists in a bid to break down systemic obstacles. These include the Science in Australia Gender Equity program. Others aim to inspire women to study STEM subjects, such as 'Code like a Girl' or to help young women build their techno-confidence, such as 'SheFlies' and 'Robogals'.

Adding to this picture, Superstars of STEM aims to address public perception and is founded on the principle that visibility matters [1] in achieving equality.

Rather than simply attempting to shoehorn women into the public eye, this new program will work with 30 women in STEM to equip them with the skills, confidence and opportunities to become role models. This approach will build on the work being done to address systemic issues facing female scientists and technologists.

A recent European study by Microsoft found that most girls became interested in STEM at around the age of 11, but their interest began to wane at 15 [2]. This is an important age, as girls are starting to make decisions that will set the trajectory of their academic life.

The lack of role models in STEM was identified as the key factor that influenced the girls in the study, as well as a lack of practical experience with STEM subjects at school. On Twitter, 92% of the most followed scientists are male [3]. When women scientists are mentioned in the media, they often tend to be described by their appearance rather than their achievements [4].

The need for more female STEM role models has also been echoed in similar reports and programs in Asia, the UK, Africa and the United States.

In Australia, more than half of all undergraduates and half of PhD students are female. Almost 60% of junior science lecturers are women [5]. But women comprise just 16% of top-level science and technology researchers, professors and professionals [6].

Role models

As a young kid gazing at the stars, my role models were pioneering astronauts like Neil Armstrong and Buzz Aldrin, and eccentric types such as the late, great astronomy broadcaster Sir Patrick Moore.

I thought that was enough for me, until as a 16-year-old I met Britain's first astronaut, Helen Sharman, at Space School UK. At that moment I suddenly realised that every one of my role models in the fields of astronomy and space science had been male.

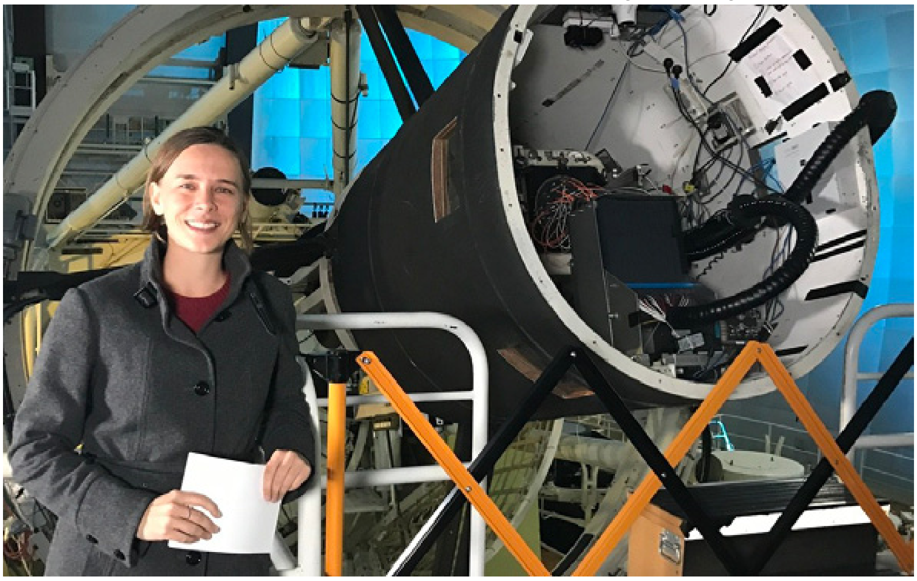
Meeting this real-life STEM superstar had a transformational influence on me. It even spurred me on to apply for the European Astronaut Program in 2009.

As someone who is passionate about astrophysics and science education I have inadvertently become a role model myself.

But the continued lack of diverse role models in STEM makes me wonder how many missed opportunities and how much unrealised potential continues to be lost. Have our young, modern-day Marie Curies, Ruby Payne-Scotts, Ada Lovelaces and Isobel Bennetts passed up on science as a subject in favour of more conventional choices?

The new superstars

In its first year, Superstars of STEM is placing 30 women in the public eye, by equipping them with advanced communication skills. This will include media training, meetings with decision-



The new Superstar in STEM ambassador Lisa Harvey-Smith at the Australian Astronomical Observatory's 3.9m Anglo-Australia Telescope at Siding Spring Observatory.

makers, and opportunities to showcase their work.

Participants will also be supported to speak with girls directly at local high schools and public events, along with establishing a public profile online.

There are too few transformational and brilliant women in the public eye. Every success in science and technology in Australia is built on the work and contributions of people across the genders. For the sake of our girls, we need to celebrate these outstanding scientists and their work.

I imagine a time when we ask children to draw a scientist and they draw somebody who looks like mathematician Nalini Joshi, molecular biologist Suzanne Cory, or astronomer Karlie Noon.

The measure of the success of Superstars of STEM will be whether young Australian women can turn on the television, read a newspaper or engage with social media and see women experts presenting STEM as an exciting and viable career. I can't wait to witness the opportunities this change will bring.

References

[1] KR Monroe et al, *Gender Equality in the Ivory Tower, and How Best to Achieve It.* Political Science & Politics, **47**(2), 418-426 (2014).

[2] news.microsoft.com/europe/features/dont-european-girls-like-science-technology/#sm.00014rslxwraaezk114r3i35yti9g#mZefJwMG5tOHq5he.97

[3] sciencemag.org/news/2014/09/top-50-science-stars-twitter

[4] M ChimbaJenny Kitzinger, *Bimbo or boffin? Women in science: an analysis of media representations and how female scientists negotiate cultural contradictions*, Public Understanding of Science, **19** (5), 609-624 (2009).

[5] womeninscienceaust.org/2014/06/15/women-in-the-scientific-research-workforce-identifying-and-sustaining-the-diversity-advantage/

[6] sciencegenderequity.org.au/gender-equity-in-stem/

This article was co-authored with Kylie Walker, Chief Executive Officer of Science and Technology Australia.

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The orignal article can be found at: theconversation.com/the-hunt-for-the-superstars-of-stem-to-engage-more-women-in-science-76854

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Lucky Imaging of Low Earth-Orbit Satellites

by Anna Zovaro, Michael Copeland, Francis Bennet, and Rob Sharp

Human kind is becoming increasingly dependent upon satellites to provide essential services such as telecommunications, mapping, remote sensing and geodesy, with over 103 operational satellites in orbit around Earth today. Far greater in number, however, are pieces of orbital debris - including defunct satellites, rocket bodies, and even flecks of paint - which have slowly accumulated in number, especially in low Earth-orbit (LEO) (orbits with an altitude below 1000 km), populous orbits that are well-suited to satellites used for telecommunications and mapping.

Objects in LEO have a speed on the order of 10 km/s, meaning that a collision between an operational satellite and something as small as a ball bearing can cause catastrophic damage. Perhaps more importantly, detritus from the orbital collision can go on to collide with other objects, creating a cascade of collisions and an exponential rise in the density of orbital debris, a situation known as Kessler syndrome [1]. In this scenario, the probability of a satellite colliding with debris approaches unity, rendering the orbital environment essentially unusable. Given our increasing reliance on satellites, preventing in-orbit collisions has never been more critical, particularly as we prepare for the next era of manned spaceflight.

Satellites with thrusters can be manoeuvred out of harm's way if a collision is predicted. Producing timely warnings for these collisions relies upon accurate trajectory predictions, generated using orbital propagation models. In LEO, objects are subject to a number of non-gravitational forces - those from atmospheric drag, solar radiation pressure and the Earth's magnetic field, just to name a few. For large objects, the magnitudes of these forces may depend heavily upon the object's attitude (i.e. its in-orbit orientation), spin rate and geometry, and can be significant sources of orbital perturbation.

Operational satellites can transmit information about their current orientation and spin rate down to Earth. Debris cannot, however, meaning that ground-based observations are currently our only means of predicting collisions involving debris.

RADAR and satellite laser ranging (SLR) techniques are only able to provide accurate angular and range measurements of orbiting objects, whereas light curve measurements can be used to estimate spin rates. Although they may be highly accurate, these measurements cannot provide precise information about the status of extended structures such as solar panels, which can significantly alter the object's non-gravitational dynamics. Without this information, it is all but impossible to make accurate estimates of the non-gravitational forces acting upon an orbiting object. Omitting these forces from orbital propagation models can cause trajectory predictions to become woefully inaccurate just days after measurements are made, rendering us unable to predict when a collision may occur.

High-resolution images of a satellite or debris object at visible wavelengths can enable direct measurements of its spin, orientation and geometry, and are therefore a powerful complement to existing measurements. However, imaging of LEO objects is currently only feasible using ground-based telescopes, which are limited in resolving power by the atmosphere.

Turbulence causes fluctuations in the atmosphere's refractive index, distorting wavefronts of light as they propagate to the ground from space. The time scale of these fluctuations is on the order of milliseconds, meaning that images captured with exposure times on the order of minutes become distorted and blurred, obscuring fine details. The angular resolution of the image - that is, the smallest angular size of details that can be resolved - is effectively increased from the telescope's diffraction limit λ/D, where λ is the imaging wavelength and D is the telescope diameter, to λ/r_0, where r_0 describes the scale length of turbulent cells. r_0 typically ranges from 5-20 cm at visible wavelengths, leading to a dramatic worsening in imaging resolution for telescopes with primary mirrors larger than a metre in diameter.

Adaptive Optics (AO) systems are designed to correct atmospherically-induced wavefront aberrations in ground-based optical telescopes, enabling near-diffraction-limited imaging.

A schematic of a simple AO system is shown in Figure 1. A basic AO system involves a wavefront sensor, which measures the shape of the incoming distorted wavefront, and a deformable mirror, a mirror with a flexible face sheet that is used to correct the distorted wavefront. Alongside a computer to handle the control logic, these components are arranged in a closed-loop feedback architecture that corrects wavefronts coming into the telescope before they propagate to the imaging camera. The wavefront correction manifests as an improvement in imaging resolution, with an ideal system enabling diffraction-limited imaging by perfectly flattening the distorted wavefronts.

AO systems have been used for decades in astronomy. However, today AO is used in many applications, ranging from retinal imaging to laser-based telecommunications.

A novel application of AO is in imaging satellites with ground-based telescopes.

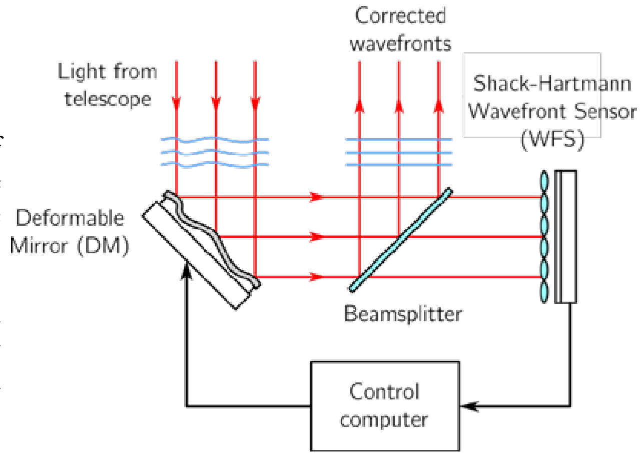

Figure 1. A schematic of a simple closed-loop AO system.

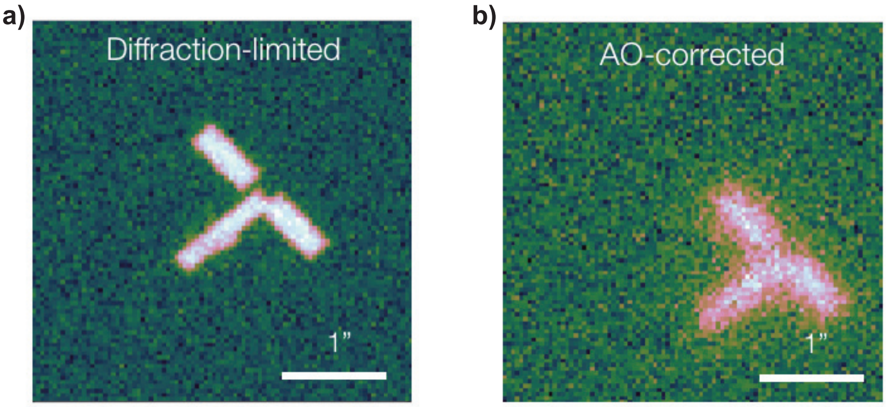

Figure 2. Simulated short-exposure time images of an Iridium satellite orbiting at an altitude of 780 km imaged through a 1.8-metre telescope through a broad-band filter with central wavelength of 800 nm; (a) shows the diffraction-limited image and (b) the AO-corrected image with atmospheric turbulence.

For the last few years, the AO group at the Australian National University (ANU) has been developing AO systems specifically suited to satellite imaging in partnership with Electro-Optic Systems (EOS) with funding from the Space Environment Research Centre (SERC). The KASI-AO system, an AO system commissioned by the Korea Astronomy and Space Science Institute (KASI) for a telescope with a primary mirror 1 metre in diameter, was successfully delivered in 2016. Currently, the AO group is developing the Adaptive Optics Imaging (AOI) system, a more sophisticated iteration of KASI-AO that will be deployed on the EOS 1.8-metre telescope at Mount Stromlo Observatory. Figure 3 shows images of a star that were captured with the KASI-AO system on the 1-metre telescope at Mount Stromlo Observatory with both the AO on and off, demonstrating the substantial resolution improvement.

Nonetheless, AO correction alone is rarely sufficient to enable diffraction-limited imaging, as shown in Figure 2.

A technique to improve imaging resolution beyond that which can be achieved with AO is Lucky Imaging (LI). LI relies on taking hundreds of short-exposure-time images, with the aim of capturing a `lucky' frame every now and then - that is, a near-diffraction-limited image in which the wavefront captured by the telescope is nearly flat. For this to work, the exposure time must be short enough to `freeze out' the atmospheric turbulence; at visible wavelengths this time scale is on the order of milliseconds. The `luckiest' frames are then fused using a number of different techniques, producing a single image with a resolution superior to that of any individual frame.

Although LI has been used by professional and amateur astronomers alike for decades to enhance images of stars and galaxies, its application to imaging satellites has been limited by several factors:

1. **Observing windows for satellites in LEO are short.** LI techniques work best when the sequence of images is longer, simply because there is a higher probability of capturing `lucky' frames. LEO satellites - which have orbital periods of 1-2 hours - only remain in view from an observer on the ground for short periods of time, meaning that only minutes' or seconds' worth of images can be obtained. Furthermore, unlike stars and galaxies which are their own light source, satellites can only be seen when illuminated by the sun. Additionally, to be visible against the sky, satellites must be observed when the sky is dark, limiting observation times to dawn and dusk.
2. **The appearance of a satellite in LEO changes as it passes overhead.** To apply LI techniques to a series of images, the object's appearance must remain constant. The viewing angle to the satellite changes as it passes overhead, and many will also be spinning, further limiting the length of image.
3. **Capturing images of satellites in LEO with sufficient resolution to provide any useful visual information has been very difficult without AO.** Unlike astronomical targets, satellites move at high speeds with respect to the sky. As a result, the wind speed `seen' by the telescope is increased, which effectively worsens the distorting effects of atmospheric turbulence. Without AO, it is virtually impossible to capture a sufficient number of images containing enough high-resolution information to resolve useful details when LI is applied.

Due to these difficulties, no in-depth studies of applying LI to imaging of LEO satellites exist in the literature as of 2017.

In light of the need to maximise the imaging resolution that we will be able

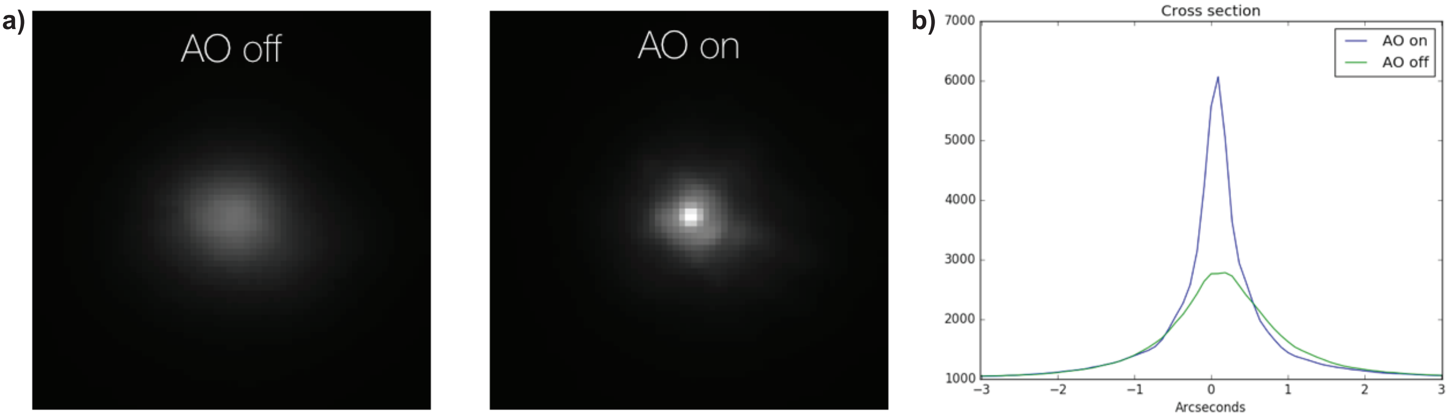

Figure 3. (a) Long-exposure time images of a star captured using the KASI-AO system on the 1-metre telescope at Mount Stromlo Observatory, with the AO system off (left) and on (right); (b) cross-sections of each image.

to achieve with the AOI system, we have applied a range of LI techniques to AO-enhanced images of satellites in order to determine which methods are most effective. The data sets included images of a satellite in the Iridium constellation that were generated using an AO-enhanced imaging simulation code, in order to simulate those that will be produced by the AOI system. We also applied the LI techniques to real images that were captured using the KASI-AO system when it was being tested on the 1-metre telescope at Mount Stromlo Observatory in September 2016.

The LI techniques that were applied can be classified into two broad categories: classical and Fourier plane.

Classical LI methods use a basic `shift-and-stack' method to combine images. In addition to the fine details of the object becoming distorted, atmospherically-induced wavefront distortions manifest as random shifting of the object from its nominal position in the image. In long exposures, these time-varying shifts cause a Gaussian blurring effect, which is demonstrated in Figure 3. The simplest LI techniques involve removing the shift from each image, followed by median- or mean-combining them, which effectively suppresses the noise in the resultant image.

Removing the shift, however, first requires determining what the shift is. For point sources such as stars - in which the majority of the light is concentrated over a small number of pixels - the shift can be determined from the location of the pixel with the peak value. This technique is useful for imaging faint, diffuse objects such as galaxies that are close to bright foreground stars which can be used as a `reference'.

However, for extended, diffusely reflecting objects such as satellites - in which the brightest regions of the object may be large or disconnected - the location of the peak pixel may not correspond to the object's shift in the frame, as evidenced by Figure 4.

Here, we investigated more advanced techniques better suited to these extended sources.

The centroid, or the intensity-weighted centre of the image, is well-suited to determining the position of a bright object on a dark background. We find the centroid technique to be effective in images with high signal-to-noise ratio (SNR), when the satellite is bright or when the sky is dark; however, when the SNR is low, the centroid becomes biased towards the centre of the image. When the SNR is sufficiently low, the centroid method performs no better than the `blind' shift-and-stack, in which no shift is applied at all; this is demonstrated in Figure 4.

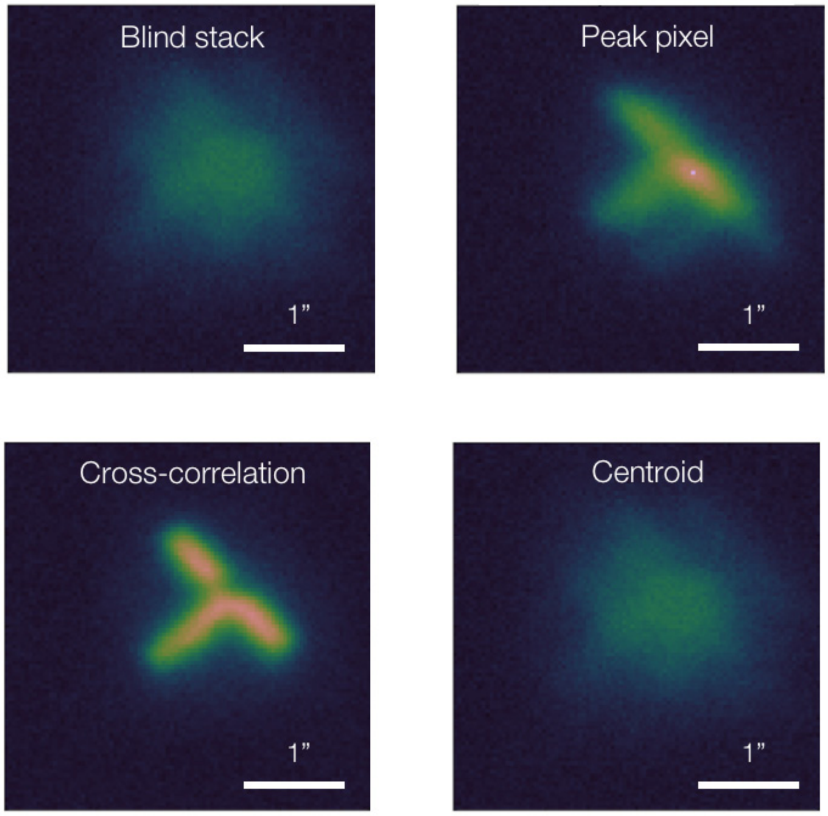

Figure 4. Images generated by applying different shift-and-stack LI methods to a series of 60 simulated frames depicting an Iridium satellite imaged through the AOI system. From top left, going clockwise: `blind' stack; peak pixel; cross-correlation and centroid shift techniques.

A better method involves using the cross-correlation. The cross-correlation of two images which are similar, but shifted with respect to one another, will be a Gaussian-like surface with a peak at the location corresponding to the shift. In this technique, the cross-correlation of each frame with the first one in the series is used to determine the shift. As shown in Figure 4, the cross-correlation is the most robust of all three shift-and-stack methods, working well even when the SNR is low, because the cross-correlation is largely unaffected by random background noise.

In many applications of the shift-and-stack technique, only a fraction of the `best' images are combined. Most often the frames are ranked by the peak pixel value in the image, because the flux in the image tends to become more spread out as the wavefront becomes more distorted. Using frame selection rates (FSRs) of 1-10% has been shown to be highly effective [2].

However, the shift-and-stack method is an `all-or-nothing' process: when using an FSR < 1, out of thousands of exposures taken, only a handful of images may actually be used. In any given image, there is likely to be some `good' information - for instance, the resolution in the horizontal direction may be near-diffraction-limited, but much poorer in the vertical. Using the peak pixel shift-and-stack method with an FSR < 1 is bound to throw away many such images containing valuable information about the true appearance of the object. Conversely, the final image will contain some poor information from those frames that are kept. This becomes a problem when imaging LEO satellites, because there may only be ~ 100 or so frames to begin with.

A better LI technique will be able to fuse an image from select bits of information from all images, discarding the rest; such a method is the Fourier Amplitude Selection (FAS) method, in which the ranking and selection of information is performed in the Fourier plane.

The method relies on the fact that

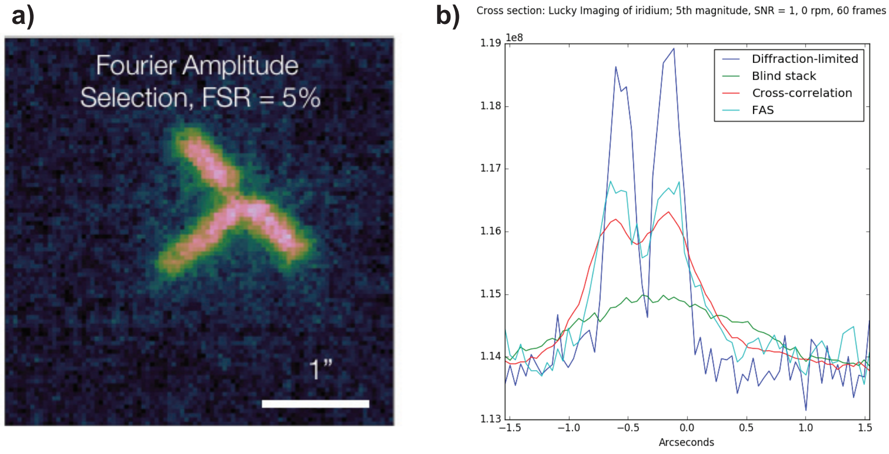

Figure 5.(a) An image produced using the FAS method with an FSR of 5% and (b) a comparison of cross sections of the images produced using the `blind stack', cross-correlation and FAS (with an FSR of 5%) LI methods with the diffraction-limited image.

atmospherically-induced wavefront aberrations decrease the amplitude of Fourier components at all spatial frequencies [3]. For each pixel in the Fourier plane, the spatial frequency components in each image are ranked based on their amplitudes, and an image is reconstructed from the top 1-10% of components from all images at each spatial frequency. The FAS method is inherently more efficient than the shift-and-stack method, because the selection of information is done within each image, rather than of each image as a whole.

We adapted the FAS methods of [3] and [4] to our data sets, finding it to produce sharper images than the cross-correlation technique, as shown in Figure 5. The FAS method emphasises the sharp corners of the solar panels and the satellite body, whilst increasing the flux across the body of the satellite, as shown in Figure 5b.

After optimising the parameters of the shift-and-stack and FAS LI algorithms on the simulated image data, they were applied to real data captured using the KASI-AO system on the 1-metre telescope at Mount Stromlo Observatory. Figure 6 shows the results obtained when applying the different techniques to images of Resurs-DK, a Russian satellite orbiting at an altitude of roughly 560 km.

The trends observed in the performance of different LI methods when applied to the simulated image sets were reflected in the real data, confirming the methods' efficacy. Again, the FAS technique was found to be the most effective; in the FAS image, the shape of the solar panels is clearly resolved, as well as a reflective structure on the satellite's body.

Our results show that LI is useful in more applications than just astronomy, and may help us to avoid in-orbit collisions and in turn the onset of Kessler syndrome. In spite of the challenges associated with imaging orbiting objects from the ground, LI can dramatically improve the imaging quality that can be achieved using ground-based telescopes equipped with AO. In particular, novel Fourier-space techniques have been shown to enable structural details of satellites to be resolved, a feat simply not possible without the use of LI. The AOI system is expected to see first light in 2018; by providing high-resolution imaging capability, systems such as these will hopefully enable us to preserve the space environment for

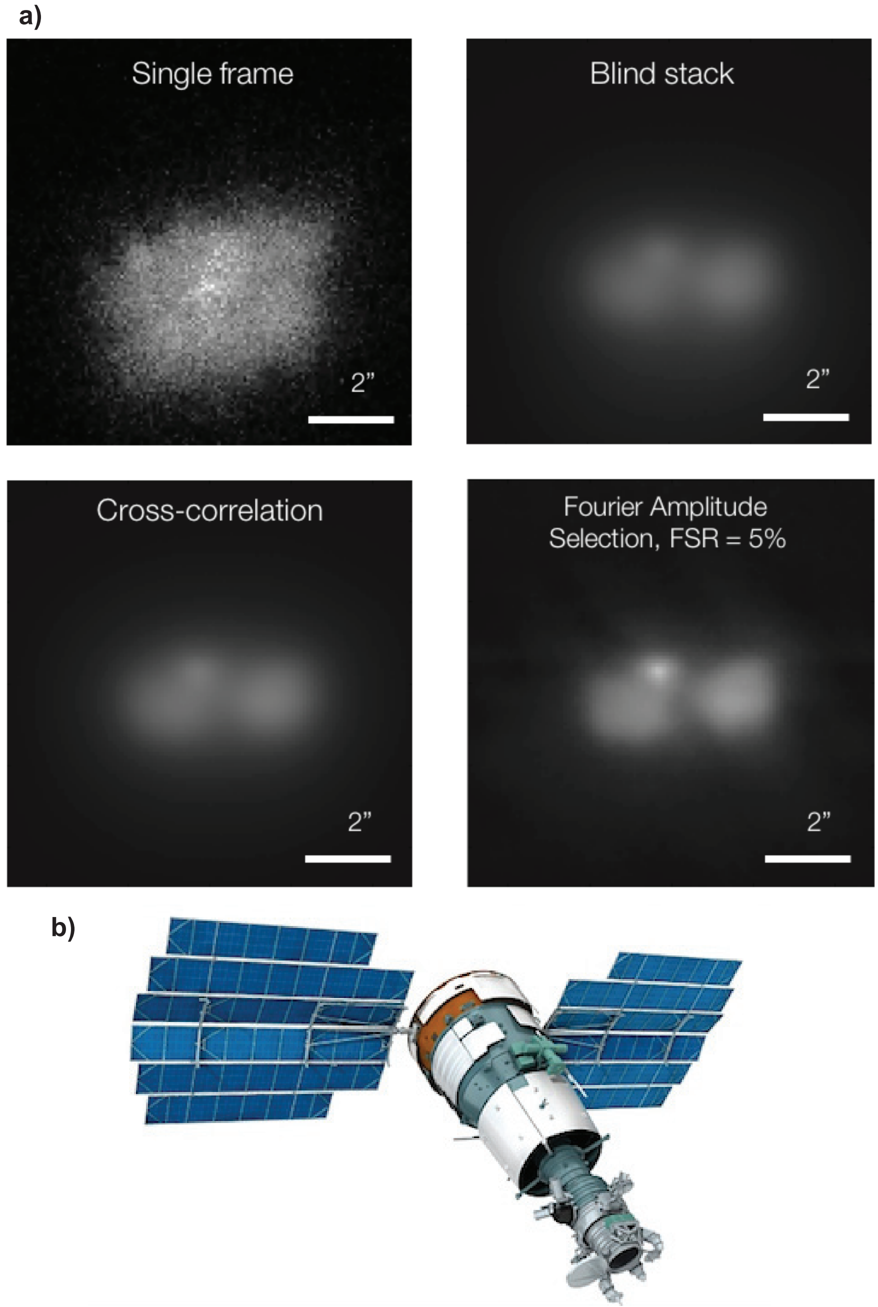

Figure 6. (a) Images produced by applying different LI techniques to a series of images of the Russian Resurs-DK satellite, captured with the KASI-AO system on the 1-metre telescope at Mount Stromlo Observatory. The satellite is shown in (b) (image courtesy TsSKB Samara).

generations to come - with just a little bit of luck involved.

Acknowledgements
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References

[1] Donald J Kessler and Burton G Cour-palais. *Collision Frequency of Artificial Satellites: The Creation of a Debris Belt.* Journal of Geophysical Research, **83**(8):918-924 (1978).

[2] Andrew Smith, Jeremy Bailey, JH Hough, and Steven Lee. *An investigation of lucky imaging techniques.* Monthly Notices of the Royal Astronomical Society, **398**(4):2069-2073 (2009).

[3] Vincent Garrel, Olivier Guyon, and Pierre Baudoz. *A Highly Efficient Lucky Imaging Algorithm: Image Synthesis Based on Fourier Amplitude Selection.* Publications of the Astronomical Society of the Pacific, **124**(918):861-867 (2012).

[4] Craig Mackay. *High-efficiency lucky imaging.* Monthly Notices of the Royal Astronomical Society, **432**(1):702-710 (2013).

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News

IUPAP Young Scientist prizes

AOS member Dr Mohsen Rahmani from ANU has won the 2017 International Union of Pure and Applied Physics Young Scientist Prize in Laser Physics and Photonics (Fundamental Aspects) "for his outstanding contributions to light-matter interactions at nanoscale, particularly nonlinear nanophotonics via metallic, dielectric and semiconductor nanostructures and metasurfaces, which have paved the road for extending nonlinear optics to nanoscale". Moshen's work received media attention recently, with articles in national newspapers about the potential applications of his work to night vision glasses.

Dr Rahmani is currently an Australian Research Council Discovery Early Career Research Award holder at the Australian National University. Until recently he was a research associate at the Blackett Laboratory, Imperial College London, United Kingdom; following a PhD from the National University of Singapore, Singapore (2013).

The 2017 IUPAP Young Scientist Prize in Laser Physics and Photonics (Applied Aspects) was also awarded to an Australian based researcher. A/Prof Igor Aharonovich from University of Technology Sydney won "for his outstanding contributions to research on quantum emitters in wide band-gap semiconductors".

A/Prof Aharonovich is currently at UTS where he leads the Nanophotonics research group. Previously he was a postdoctoral fellow at Harvard University, Boston, United States; following a PhD (2010) at University of Melbourne, Australia; and a BSc (2005) & MSc (2007) from Technion – Israel Institute of Technology, Israel.

iupap.org/commissions/c17-laser-physics-and-photonics/c17-news

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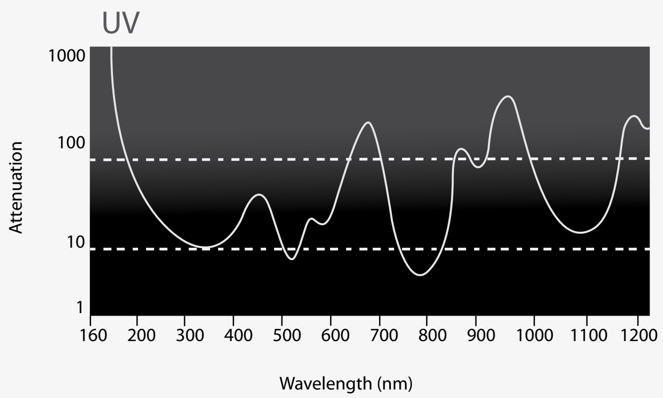

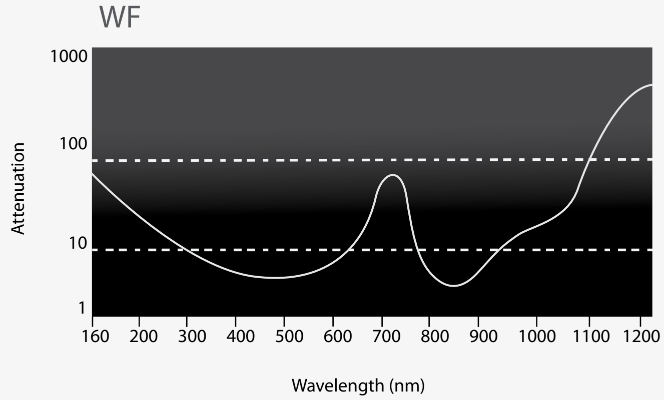

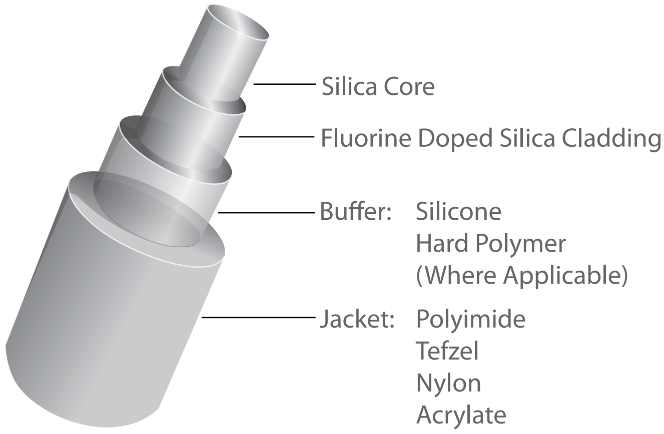

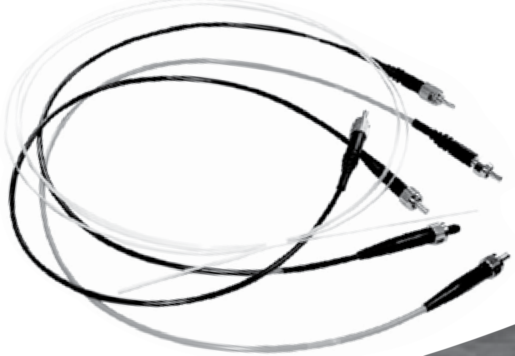

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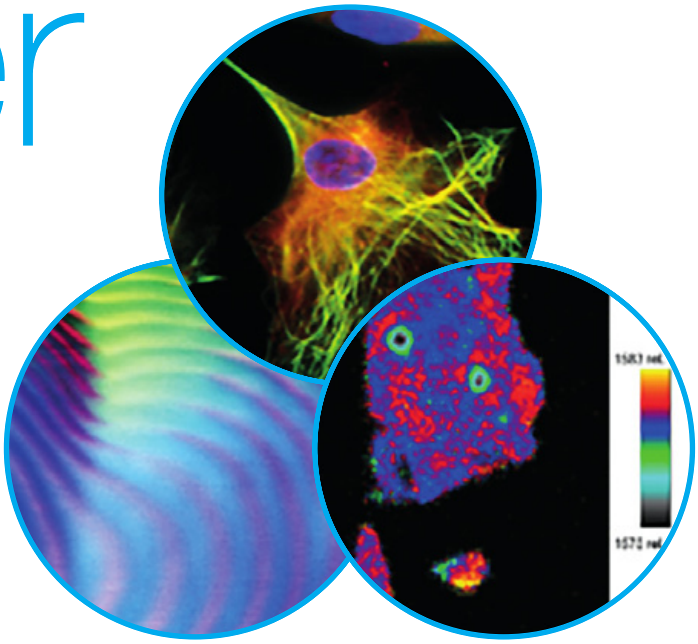

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A Theory of Nothing: a Novel Approach to Exposing How Science Really Works

This article was originally published on
THE CONVERSATION
by Cathy Foley

Have you ever wondered what inspired the United States to initiate the mission to put a man on the Moon? Or who first thought of building the Large Hadron Collider or the massive Square Kilometre Array radio telescope? What is it that prompts these multi-billion-dollar scientific projects to start? This is the issue explored by Australian author Thomas Barlow in his first novel, A Theory of Nothing, published last November and which I had the chance to revisit over the summer holiday.

Barlow's previous work tends to focus more on the factual coverage of science and innovation in Australia and beyond, including the regular Barlow Advisory on the Australian research and development system with a particular focus on universities.

His first work of fiction, though, clearly draws on his experience of dealing with people in scientific research. Barlow touches on some sensitive issues that we scientists don't always like to acknowledge.

But A Theory of Nothing didn't start out as a Barlow publication. Barlow originally self-published this novel with the title Critical Mass as a fictional autobiography of the protagonist, Professor Duronimus Karlof.

Early feedback from scientists and administrators gave Barlow the confidence to tighten up the story a little, to change some character names to protect the innocent and republish with a new title under his own name.

Into the novel

The novel begins with Prof Karlof, a physicist and rising star of Harvard University. The inspiration for setting up his major project is the death of a colleague, Sandra Hidecock, a renowned professor of natural law with many accolades.

Hidecock apparently jumped to her death from her office window as she challenged the laws of nature because she was opposed to their "soulless and frigid constraints".

In support of Hidecock, Karlof somewhat reluctantly initiates the Ooala Project, a billion-dollar project to, as he puts it, "have a go at the laws of nature".

Securing his first million dollars from the president of Harvard's slush fund, Karlof goes about creating his handpicked multidisciplinary team of five of the leading second-rate scientists at Harvard.

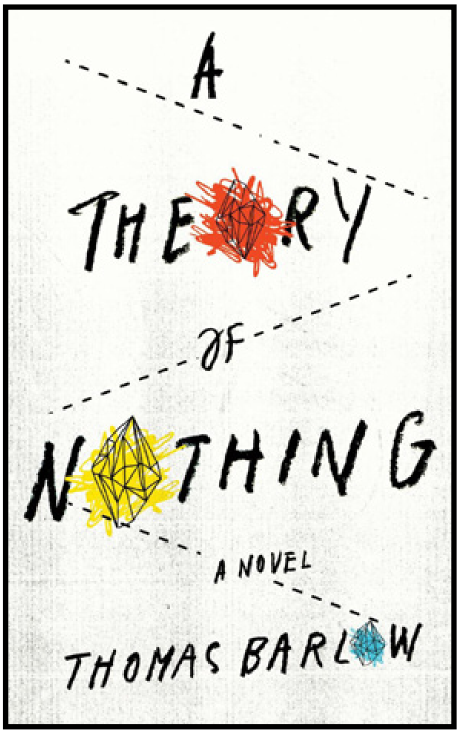
They were the "disaffected scholars" who "rarely published in the top journals and whose careers had never lived up to their self-imagined promise". These were the ones who wanted to "feel important again" and "their backing would be easy to obtain". In return they would receive "kudos […] and re-ignite in their hearts a sense of mission and destiny".

Having assembled his B-team, they decide that the focus of the Ooala Project should be creating sub-stationary motion. They would create an environment that slows matter down to being stationary compared to all other points of the universe and then slow the matter down more to be "beyond stationary!"
And so it begins.

Karlof builds an international research community including a professional society and a journal. He secures secret defence funding and creates international collaborations.

Karlof attracts additional funding of more than a billion dollars. He builds an extraordinary facility in the Nevada desert, complete with a new-concept electricity generator. He has a community of students living on site in a Manhattan Project-style remote community, all working together to show that the laws of physics are not as they seem.

He even discovers a new "negatronium particle", an invisible, massless entity that reduces the mass of anything with which it collides.



A Theory of Nothing, by Thomas Barlow. Image credit: Thomas Barlow.

More than just a story

But the satirical novel is more than a fun raspberry blown at the establishment of international science. Barlow has woven several important themes into a very engaging and humorous story.

He shows how the human element is a critical requirement in the scientific process to build a new research field. He suggests how supporting the best and brightest leader, regardless of the quality of the team, can lead to an extraordinary and unexpected impact on society.

Although it's a cynical view of how to set up a major research project, Barlow delves into the investment in science by politicians based on a scientist's reputation.

He shows too clearly how to buy collaborators, revealing that scientists follow the research money and jump on research bandwagons regardless of what they think of the research quality and whether it's "good" science.

Barlow also has a dig at the public service and the silly consequences of secrecy and the unexpected ways that fundamental research can impact society due to completely unforeseen applications in disparate fields.

In this case, because the "negatronium particle" affords a mechanism to "cross the boundary between the physical and the psychological", the US Treasury uses the impact of this new particle on controlling human emotion to match government financing failures with policymarkers' expectations. In doing so they create compliance.

And, finally, Barlow demonstrates his strong underlying support for women in science. On trying to find a female to make up a diverse B-team, Karlof "didn't know any second-rate women".

He finds Assistant Professor Millicent Parker on the recommendation of the Dean of Engineering and Applied Sciences, who describes the female professor as "very good – very competent". Parker adds:

[…] but she's too generous with her time. She takes on too many responsibilities […] She writes half my papers for me, she has twice the teaching load of the male assistant professors and if any student runs into trouble, she's always the one they go to. She doesn't leave any time for herself.

Based on Barlow's experience of real people in the research community, perhaps?

But for Karlof, Parker is a "perfectly sensible person: conscientious, considerate […] a woman with excessive helpfulness". He believes she will create a great culture, encouraging everyone to pitch in and work together for a common goal.

Fiction or faction?

This book could be seen as a shift for Barlow from his razor-sharp evaluation of innovation in his non-fiction books The Australian Miracle: An innovative nation revisited (2006) and Between the Eagle and the Dragon (2013).

I see this as Barlow using his novel as a different genre to make us think about how science is "done". It questions if we are really approaching the creation of new knowledge in the best way via the constructs built up over the years to create a science industry of sorts.

He also reveals the bitterness of a scientist when their success leads to loss of control of their work once it is taken over to be applied to practice.

A Theory of Nothing is, above all else, a great read. It is funny and the characters (intentionally or not) do capture the personalities of science, not just in Australia but internationally.

Barlow also captures the human dimension of multidisciplinary research teams, personal ambitions and the rise and fall of a scientific career that is dependent on your latest project's success.

If you are a scientist, you will love the cynical description of a clever person playing the system. And for the non-scientist it provides a hilarious exposé of the way major projects start.

I just hope that our new science minister did not read it over the summer holiday.

Cathy Foley is Deputy Director and Science Director Manfacturing Flagship, CSIRO.

The original article can be found at: theconversation.com/a-theory-of-nothing-a-novel-approach-to-exposing-how-science-really-works-71155

Conferences

26 November to 1 December, IONS KOALA 2017

IONS KOALA is the Conference on Optics, Atoms and Laser Applications (KOALA) held annually in Australia and New Zealand as well as an International OSA Network of Students (IONS) conference sponsored by The Optical Society (OSA). IONS KOALA 2017 is being co-hosted by the OSA student chapters at the University of Queensland and Griffith University in Brisbane from 26 November to 1 December. "With the support of many fantastic organisations, our goal is to bring together a large groups of Honours, Masters and PhD students currently conducting research in any field of optics, atoms and laser applications in Australia, New Zealand and the world."

KOALA encompasses a broad variety of topics within the field of optics and photonics. These include but are not limited to atomic, molecular and optical physics, quantum optics, spectroscopy, micro and nanofabrication, biomedical imaging, metrology, nonlinear optics and laser physics research. Most attendees are at the very beginning of their careers, so this is a great way to discover a wide range of possible directions within the world of optics and photonics!

KOALA is designed to allow students to discuss their research whilst providing them with a chance to network with their peers who are working in various universities across a variety of fields. The aim is that students gain a fresh perspective as well as the opportunity to learn about exciting research being conducted. Students will also get the chance to develop valuable communication skills through presenting their research to their peers working in a variety of fields. ionskoala.osahost.org

3-7 December, Australian and New Zealand Conference on Optics and Photonics 2017 (ANZCOP 2017)

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 2013 was held in Perth and ANZCOP 2015 was held in Adelaide.

ANZCOP 2017 will be held in Queenstown, New Zealand, 3-7 December 2017.

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Product News

Ophir Photonics RM9 with chopper

Measuring optical signals in the femtowatt (10^{-15}) to nanowatt (10^{-9}) range can be a daunting task. Signals this low are lost in typical detector noise levels and swamped by background light. The noise floor for photodiode detectors operated with a small bandwidth (~10 Hz) is on the order of 1 picowatt (10^{-12}).

In order to achieve significant improvements in noise rejection we need to turn to a lock-in amplifier. The key to high performance with a lock-in amplifier is maintaining a precise match between the modulation frequency of the signal to be measured and the frequency of the reference signal. Many low level optical signals that need the benefits of a lock-in amplifier are DC or very low frequency. In these applications, an optical chopper is used to modulate the signal.

Ophir's RM9 family of sensors incorporate a compact, dedicated lock-in amplifier, an optical chopper and a selection of sensitive detectors in an easy to use system for measuring ultra-low signal levels even in the presence of much larger background noise.

This sensor family provides high performance for a wide range of demanding applications such as spectroscopy, THz detection, free space gas analysis, atmospheric studies, Raman scattering, and many others.

Ophir Spiricon products and calibration services are available from Raymax

HyperFine Spectrometer

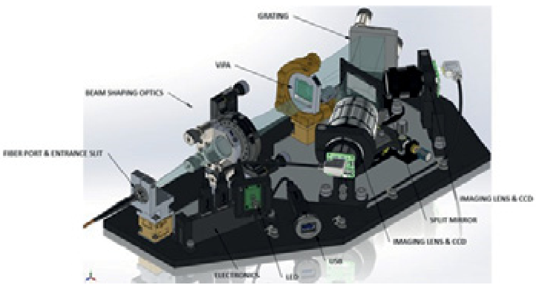
The HyperFine series of spectrometers are based on LightMachinery's patented VIPA technology. Designed for measuring hyperfine spectra and subtle spectral shifts, the HyperFine spectrometer from LightMachinery is a compact, low cost spectrometer capable of sub-picometre resolution. It is ideal for pulsed laser characterisation and for measuring the small spectral shifts from Brillouin scattering. Simple PC based software allows the user to review spectra in real time and save or export for more analysis. LabView drivers enable the HyperFine spectrometer to be integrated into automated experimental setups.

How does it work?

Light enters the HyperFine Spectrometer though a fibre or directly imaged onto the slit. A VIPA etalon, manufactured using LightMachinery's proprietary fluid jet polishing technology, is used to produce very high dispersion in the vertical axis with sub picometre resolution. This is followed by a conventional grating to disperse overlapping orders in the horizontal direction and produce a 2D spectrum of the input light. LightMachinery software unwraps the spectrum to produce an ultra high resolution wavelength spectrum of the input light. A secondary camera provides a wide wavelength range, lower resolution view of the spectrum.

Applications

- Light source characterisation
  - o Lasers of all types
  - o Single shot pulsed laser spectrum
  - o Super luminescent diodes
  - o Gas discharge lamps, etc
- Spectroscopy
  - o Plasma spectroscopy
  - o High-precision gas spectroscopy
  - o Brillouin spectroscopy
  - o Femtosecond comb fingerprinting spectroscopy
  - o Spectral-domain optical coherence tomography, etc
- Passive component characterisation
  - o Notch filters
  - o Etalons
  - o Fibre Bragg gratings, etc



Raptor Photonics launches the Falcon III with third generation EMCCD technology

Raptor Photonics, a global leader in the design and manufacture of high performance digital cameras, has launched its latest camera the Falcon III, Falcon II and Kestrel using ground-breaking EMCCD – GEN III technology.

The Falcon III incorporates a new EMCCD sensor developed by e2v which offers 1MP resolution with 10μm square pixels. A back-illuminated sensor offers a peak QE of >95% offering unsurpassed sensitivity with a total noise floor as low as 0.01 electrons readout noise.

EMCCD – GEN III offers the combination of ultimate sensitivity and speed through a single output amplifier thereby maximising uniformity. It is three times faster than previous generation EMCCDs with superior linearity and low gain performance. Up to 5000 x EM gain can be applied to the sensor using lower voltages resulting in reduced sensor ageing effects. The camera can be cooled to -100°C for lowest possible background events using Raptor's long life ruggedised PentaVacTM vacuum technology.

MicroJewel Lasers available from Quantum Composers

The MicroJewel Lasers are a series of rugged, Q-switched, Nd:YAG, DPSS lasers with an ultra-compact design delivering 8mJ at 1064nm. Reliable, light-weight and efficient, the MicroJewel lasers are ideal for commercial and OEM applications requiring small form factors.

The MicroJewel is just 3 inches long, weighs only 40 grams and has a compact, inline resonator which will reduce the space and weight limits on laser systems; with low power consumption this laser will be ideal for portable and hand-held applications. It also features an integrated thermal management system designed for applications that require high reliability. In addition, we can customise different optical configurations that are optimised for different parameters (divergence vs energy).

Specifications:
- Dimensions: .50” diameter and 3” in length
- Weight: 40 grams
- Energy Max: 8mJ
- Rep Max: 5Hz
- Wavelength 1064nm
- Compact, inline resonator
- Efficient, reliable diode pump
- Excellent shot to shot stability
- Pulse Duration (ns) 7.5 ± 1.5 @1064
- Beam divergence (mrad) ≥3.0 @1064
- Beam Diameter (mm) 1.0 ± 0.4

TOPTICA presents new TopWave CW UV laser at 266 nm

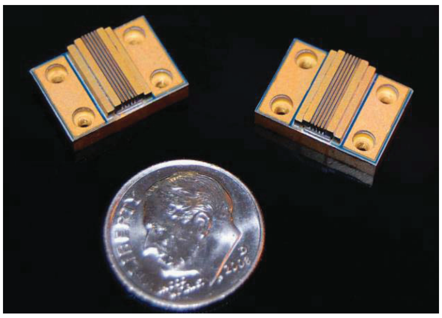
TOPTICA launches their first member of the new TopWave ultraviolet CW laser series. The "TopWave 266" provides 150 mW CW output power at a wavelength of 266 nm and < 1 MHz linewidth. It stands out with excellent power stability, ultra-low noise operation and a premium beam quality.

The TopWave laser series incorporates successful building blocks from TOPTICA's scientific tunable UV lasers (e.g. the excellent SUV cavity design) and takes the performance of these lasers to a plug-and-play level. The entire UV beam path is enclosed in an especially sealed compartment. In combination with a fully automated shifter of the SHG crystal this enables a typical lifetime > 10,000 hours, which is key for use in any industrial application.

Due to its reliability and industrial endurance behaviour, the TopWave is an excellent addition to the CW DUV laser market. Future power upgrades and additional TopWave models with other UV wavelengths will be released in the near future. The TopWave product line is ideal for applications like semicon inspection, optical lithography, laser mastering and Raman spectroscopy.

For more information please contact Lastek at sales@lastek.com.au or 08 8443 8668

High Temperature Laser Diode Arrays



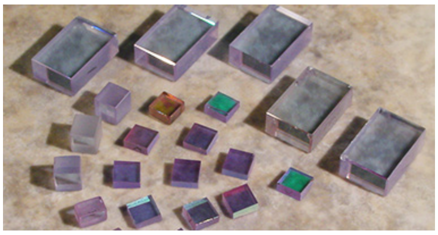
Northrop Grumman Cutting Edge Optronics is a leading manufacturer of high temperature laser diode arrays that are designed to operate in harsh environments. Diode arrays used in automotive or military/aerospace applications often experience operating temperatures ranging from 60-80°C, and CEO has a long history of supplying diode arrays that offer excellent reliability at these temperatures.

There are a variety of different bar and package types, including standard epitaxial material (excellent performance across wide temperatures) and large optical cavity epitaxial material (excellent reliability at high powers). In particular, CEO has life tested 5-bar arrays at 80°C, 250A, 60Hz for over 600 million pulses. These arrays demonstrate excellent high-temperature reliability over a pulse count well in excess of the requirement of many military applications (e.g. range finders / target designators). This pulse count is also in line with the requirements of many automotive applications.

Summary:
- NGCEO’s laser diodes can be combined with hard soldered, CTE matched packaging to create high power arrays for harsh environments
- High Density Stack arrays provide a solution if extremely high power densities are required
  - Excellent performance at duty factors ≤ 2%
- All arrays maintained good slope, threshold and E-O efficiency at temperatures from -40°C to +85°C
  - Array designs support operation at higher temperatures if desired
- 250A, 80°C life test results show that these arrays are well suited for high temperature operation
  - Less than 2.5% degradation observed per 100 Million shots at 80°C
- Lower degradation expected at temperatures less than 80°C

For more information please contact LightOptronics Aust. at rons@lightoptronics.com.au or 08 8327 1885

Solid State Laser Materials from Synoptics



Synoptics offers its customers advanced crystal growth research and development (internal and external) and is an industry leader in the manufacture of solid-state laser materials and components:

- Expertise in Czochralski, Hydrothermal and Liquid Phase Epitaxy (LPE) growth techniques
- Diverse fabrication skills in all facets of crystal fabrication from growth, cutting, drilling, grinding, polishing, thin film deposition, and inspection
- Highly talented and experienced manufacturing, measurement, and engineering support to ensure the highest quality standards are met
- World-wide staff of sales representatives
- ISO 9001:2000 certified facility

LightOptronics Aust. offer a range of Solid State Laser products:

- Laser Crystals
- Specialty Crystals
- Optical Assemblies
- Diffusion Bonding
- Custom Products & Services

For more information visit LightOptronics Aust. at www.lightoptronics.com.

Multi-channel Fibre Optic Rotary Joint

The MRn series multi-pass Fibre optic Rotary Joints (FORJs) carry the largest channel count in Princetel's FORJ line up. 20-50 independent fibre channels are offered as standard options.

The most common is 24- channel version. Loss and back reflection are uniform across all channels. There is no channel "drop off" or "blind spot" during rotation. They also feature low crosstalk performance (<60DB) for both single and multi-mode fibres.

Like our other multi-channel FORJs, all channels can accommodate either singlemode or multimode fibres. It is also possible to combine the two types of fibres in one device across three optical windows (850, 1310, and 1550 nm). As a rule of thumb, always consider lower channel count first for smaller size, lower cost, faster delivery, and easier handling. However, if massive channel count is necessary, Princetel's MRn series FORJs offer the best solution.

For more information please contact LightOptronics Aust. at rons@lightoptronics.com.au or 08 8327 1885

Andor Launches Ultrafast Spectroscopy-enabled sCMOS Detectors

Andor Technology has released an ultrafast Spectroscopy Mode on its high speed and low noise Zyla and iStar scientific CMOS cameras. Spectroscopists now have access to a unique combination of superb spectral rates, high sensitivity and high dynamic range.

The Zyla spectroscopy mode provides market leading spectral rates up to 27,000 spectra/s, ideally suited for low-light, transient spectroscopy applications with 10's of microsecond time-resolution. The Zyla's superb linearity (better than 99.8%) and zero optical etaloning in the near-infrared provide outstanding quantitative measurement accuracy. Its multi-track mode with rates up to 6,000 acquisitions/second delivers a powerful tool for hyperspectral imaging and dual-track, transient absorption spectroscopy at kilohertz rates

The iStar combines the low noise, high dynamic range and ultrafast spectral rates (up to 4,000 sps) of the sCMOS technology with nanosecond time-resolution. This combination is a highly attractive choice for plasma spectroscopy, laser-induced breakdown spectroscopy (LIBS) or pulsed fluorescence/photoluminescence spectroscopy.

Next Generation COMPex Excimer Lasers

The next generation COMPex excimer lasers from Coherent feature a compact design and easy installation and operation. They deliver superior results in demanding applications such as solid sampling systems (LA-ICPMS), material research (PLD) and precise material processing.

The next generation COMPex lasers come with superior pulse energy (750mJ at 248nm) and unrivalled pulse stability (0.75% at 248nm), ultimate pulse control, and unsurpassed safety in a standard setting footprint.

Featuring new ceramic preionisation, the COMPex provides multi-hundred milljoules output, plus unmatched pulse-to-pulse stability. The COMPex also comes with an improved gas processer that extends both gas and optics lifetimes.

For further information please contact Coherent Scientific at sales@coherent.com.au or 08 8150 5200

Nano-FTIR imaging and spectroscopy at 10nm resolution

neaspec's revolutionary technology, neaSNOM is the only microscope on the market capable of imaging & spectroscopy in the visible, infrared and even terahertz spectral region at only 10 nm spatial resolution. The neaSNOM is the ideal tool for cutting-edge nanoanalytic applications such as chemical nano-composition (nano-FTIR-mode), nano-plasmonic fields, nanoscale stress/strain fields and free charge carrier distributions.

neaspec's patented near-field detection technique eliminates the unwanted diffuse light and filters the only 1% small near-field signal out of the scattered light. Only this optical filtering technique allows 100% reproducible results at 10nm spatial resolution.

Optical imaging is performed by detecting the backscattered light interferometrically (optical amplitude & phase are acquired simultaneously) while scanning the sample surface topography. By illuminating the AFM-tip with a broadband infrared laser, an IR-spectrum of a 10nm spot is recorded (nano-FTIR).

The neaSNOM microscope combined with imaging & spectroscopy systems from neaspec thus allow the study of chemical, structural and electronic properties of a sample at a spatial resolution up to 1000-times higher when compared to conventional technology like micro FT-IR. The non-destructive measurement method is equally suited for organic and inorganic samples and requires only standard AFM sample preparation.

Nano-FTIR key features include;

- Reflective AFM-tip illumination
- Detection optimised for high-performance near-field spectroscopy
- Patented background-free detection technology
- Based on optimised Fourier-Transform spectrometer
- Up to 3 spectra per second
- Standard spectral resolution: 6.4/cm
- Upgrade to 3 cm-1 spectral resolution available
- Suited for visible & infrared detection (0.5 – 20 µm)
- Exchangeable beam-splitter mount included
- NEW: Suited for IR synchrotron sources

Helix Si APD from Excelitas

Excelitas' new HeliX Silicon Avalanche Photodiode (APD) Module is a compact, easy-to-use, analogue low-light-level detection (L³D) module employing Excelitas' leading-edge Si APD chips. The detector is in a hermetic TO package, mounted on a practical OEM based PCB which includes high-voltage power supply, temperature compensation, a low-noise transimpedance amplifier, APD bias monitor and micro-controller.

With this compact voltage-output module, the preamplifier gain is optimized to obtain maximum dynamic range and linearity with the APD at gain adjustable operating voltage. It optimises APD operation in key performance parameters such as higher sensitivity, and better signal-to-noise ratio across the 400nm - 1100nm wavelength range.

The HeliX APD module is offered with a bare 0.5mm diameter reach-through Si APD or FC-connector packaging

Key features include;

- High responsivity: 1300KV/W @ 900 nm.
- Transimpedance amplifier.
- 50Ω SMA output connector.
- Temperature compensation to stabilise gain and responsivity.
- User controllable gain and responsivity.
- Single +5V operating voltage at input provides HV and LV internal biases for APD and TIA.
- Front plate can accommodate various APDs.
- User-friendly compact footprint.
- ROHS Compliant.

Sprout-D 532nm pump laser

Lighthouse Photonics announce the release of the updated Sprout-D™ 532nm high power pump laser. The Sprout-D is a compact, diode-pumped solid-state (DPSS) laser providing up to 12 Watts continuous wave (CW) power at 532nm in a near-perfect TEM00 mode with extremely low optical noise and excellent long-term stability. Sprout-D is truly a next-generation laser designed and manufactured using many years of experience to provide a sealed, turn-key source of collimated green light with high spectral purity. There are 6 versions available ranging from 5 Watts to 12 Watts.

The laser head is a monolithic 3-dimensional design for ruggedness and compactness. The pump diode, integrated inside the laser head, has a typical mean time to failure (MTTF) of more than 50,000 hours to minimise cost-of-ownership. The compact power supply, with touch-screen control, can sit next to the laser head or on an overhead shelf. The laser head can be disconnected from the control cable for easy integration. Additional features of Sprout-D include automatic laser power control and both USB and RS-232 interfaces for external monitoring, control and remote service.

Key features include;

- Compact laser head with Seal™ enclosure for long lifetime.
- LockT™ mounting technology locks all cavity optics permanently in perfect alignment.
- Long lifetime pump diode pack integrated inside laser head.
- Extreme low noise <0.03% rms with Noise Elimination Technology (NET™).
- Bench-top, compact power supply with touch-screen control.
- Modular design with disconnectable laser head.

Optics in Everyday Life: Ring Lasers – A Brief History

by Tony Klein

Used these days in inertial navigation, ring lasers are also used in recording the tiniest variations in the Earth's spin, as well in detecting earthquakes and even the drift of continents. How did it all begin?

Back in 1914, Frenchman Georges Sagnac [1] built an interferometer in the shape of a polygon of mirrors in which counter-propagating waves from the same intense light-source could demonstrate a phase shift between the clockwise and the anticlockwise propagating waves (see figure 1).

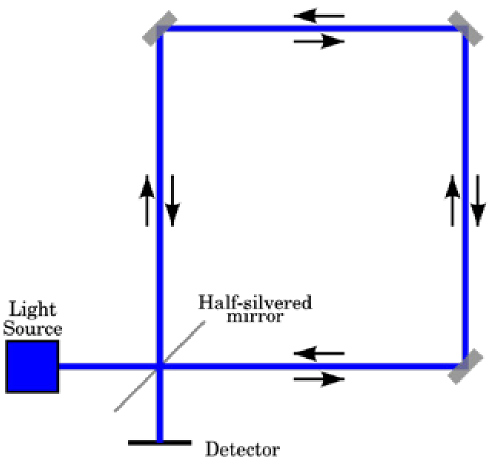


Figure 1. Schematic of a Sagnac Interferometer. Image credit: Krishnavedala.

When stationary, the two modes are degenerate, but if set into rotation, one lot of light waves from the beam-splitter are chasing the mirrors while the other lot are running into them, thereby producing a phase difference between the two beams. What Sagnac had intended to demonstrate was the speed of light relative to the "Luminiferous Ether" (which was shown to be non-existent by Einstein's Special Relativity).

The time difference effect, now named after Sagnac, may be shown [3] to be given by: $\Delta t = 4A\,.\,\Omega/c^2$ where A is the area (vector) of the polygon enclosed by the interferometer mirrors, Ω (vector) is the angular velocity of the interferometer, and c is the velocity of light. In a passive interferometer, the time difference shows up as a phase difference: $\Delta\phi = 8\pi A\,.\,\Omega/\lambda c$ where λ is the wavelength of the light source. The irony is that these formulae are true in both an ether-theoretic picture and in Special Relativity, so that the experiment didn't, in fact, demonstrate anything. This was recognised by Albert Michelson who proceeded to build his well-known Michelson-Morley experiment that did, of course, demonstrate the correctness of the Einstein theory.

However, in 1925, many years after the more famous Michelson-Morley experiment, Michelson and Gale [2] did indeed perform a "heroic" experiment aimed at detecting the Earth's rotation, by means of a huge rectangular Sagnac interferometer 612 x 339 metres in size, built in the countryside near Chicago, from evacuated 12-inch sewer pipes. I say "heroic" because the observed fringe-shift was only 0.230+/-0.005 of a fringe, but in good agreement with the theoretical prediction (see figure 2).

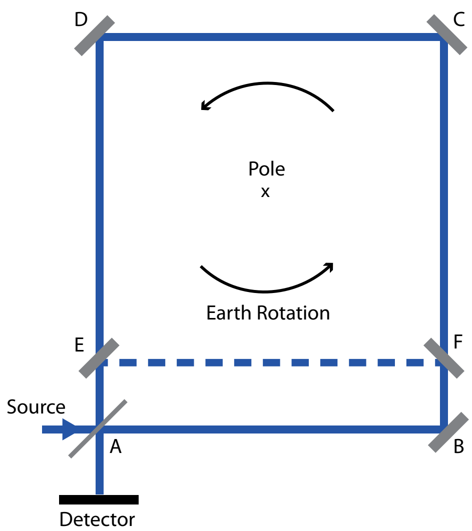


Figure 2. Schematic of the Michelson-Gale Experiment.

(In case you were wondering, they observed the difference in fringe-shifts between the interferometers (ABCDA) and (ABFEA), i.e. changing the area enclosed). There are of course other ways of proving that the Earth rotates, even without reference to the fixed stars, including the famous Foucault pendulum.

There matters stood until the year 1962 when a very interesting paper by Rosenthal[4] appeared in the Journal of the Optical Society of America proposing the insertion of active media (e.g. Helium-Neon) inside a Sagnac (i.e. a polygonal interferometer) which would then turn into a Ring Laser - see figure 3.

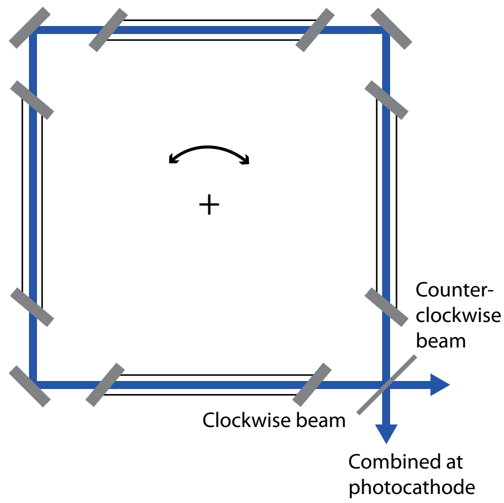


Figure 3. Schematic of a Ring laser.

In such a laser, two modes would co-exist, namely the clockwise and the anticlockwise - normally degenerate in a stationary frame. However, when in a rotating frame, the phase difference between the two modes would turn into a frequency difference i.e. a detectable beat note. The optical frequency difference between the two modes in the polygonal laser (which may be triangular or square) is given by [3]: $\delta f = 4A\,\Omega\cos\theta/\lambda P$ where A is the area enclosed, as before, Ω is the rotation rate; while θ is the angle between the rotation axis and the normal to the polygon of mirrors, and P is the perimeter of the polygon.

$(A\,\Omega\cos\theta)$ is, of course, $(A\,.\,\Omega)$, showing θ explicitly, so that the beat frequency is seen to be sensitive to both Ω and to θ, and can thus measure variations in either.

This exciting idea, for *active* Sagnac Interferometry, made everyone sit up and take notice and sure enough, it was followed less than a year later by a paper by Macek and Davis [5] demonstrating its feasibility. Thus was born the Ring Laser.

The military potential of a rotation sensor (with no moving parts), i.e. a Laser Gyro, was promptly recognised and further development became classified secret, so the scientific literature on the

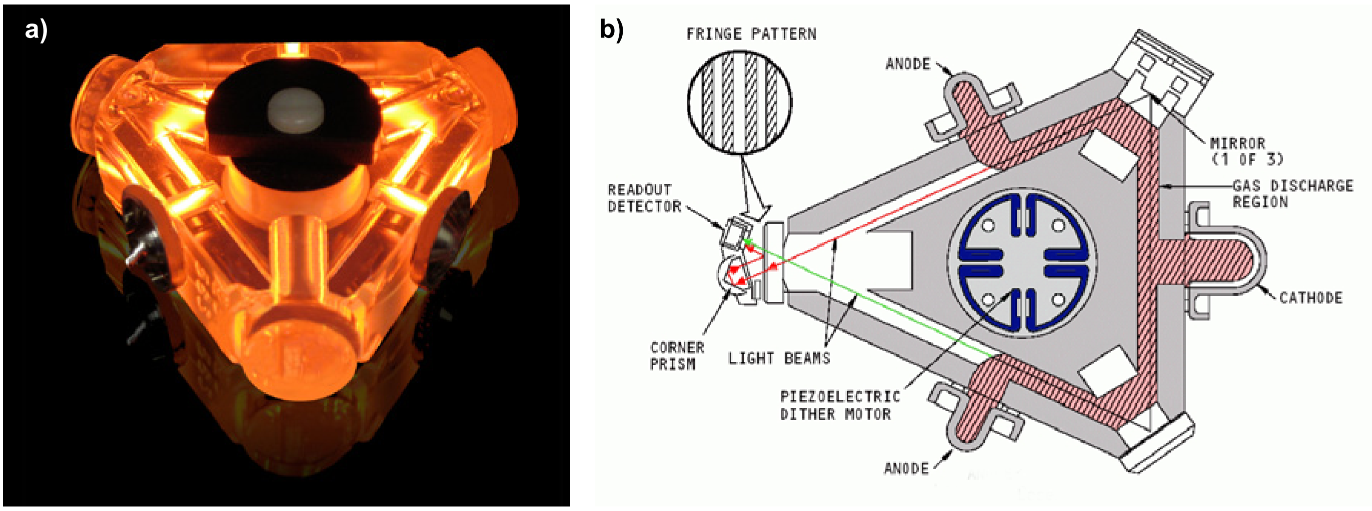


Figure 4. Laser Gyro by Honeywell a) actual and b) schematic.

subject went completely silent! Rapid progress followed all over the world and by the 1970s the Ring Laser Gyro became patented and openly published again in various forms, see figure 4a and b.

One of the shortcomings of compact ring lasers is the phenomenon of mode locking at low rotation rates. There is a minimum angular velocity below which the clockwise and anticlockwise modes simply lock together, causing zero frequency difference in the output. This is caused by parasitic phenomena, e.g. back-scattering from imperfect mirrors, and places a lower limit on measurable rotation rates. What emerged as the standard solution to this problem was in the form of motor-driven "dithering" about each of the axes, i.e. artificial rotation there and back through a small angle about zero. The resultant sinusoidal modulation of the output is easily subtracted from the signal. Highly refined complete inertial navigation packages (see figure 5a and b) became commercially available and have been in widespread use [6] since the 1980's, for example in the Boeing 747 and all airliners since (and in all missile guidance systems, of course).

An interesting variant of the Sagnac interferometer is the Fibre Optic interferometer in which the polygon of mirrors is replaced by a large number of turns of optical fibre in which the contra-rotating beams propagate, as in figure 6. Thus a very large included area A is made possible in a compact size, allowing the realisation of compact Fibre Optic Gyros – also available commercially.

But the story of the ring laser as a rotation sensor doesn't end there. In the early 1990s, Professor Geoff Steadman of Canterbury University in Christchurch, New Zealand, decided to investigate its potential in measuring tiny variations in the Earth's spin caused by various geophysical sources, such as earthquakes, tidal effects, and diurnal polar motion [6].

He built a series of large area ring lasers (with higher and higher sensitivities), first in the Physics building and later in a Second World War bunker, in the New Zealand countryside, 30m below the ground. The first instrument, with an enclosed area of ~0.85 m^2, built in 1992, was followed by larger and larger rings, with enclosed areas of 1m^2, then 3.5 m^2 the latter (first of a series) built in collaboration with the Technical University of Munich (TUM) and the German Federal Institute of Geodesy (BKG) (see figure 7a and 7b).

A large instrument, built in the German countryside with input from the famous optical firm of Zeiss, was of 16 m^2 area and included various technical improvements, principally better mirrors and better laser beam control. In this way better and better performance was obtained, initially from 1 part in a million of the Earth's angular velocity to more recently approaching 1 part per billion. In this way not only could earthquakes be detected in detail but also their aftershocks. This is because of changes in the earth's moment of inertia caused by the slippage of blocks and other subtle seismic and geodetic effects. Other

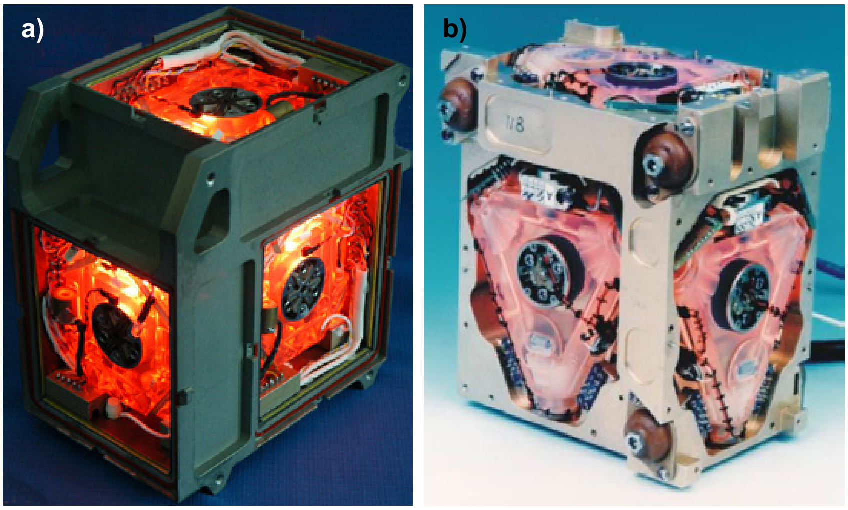


Figure 5. Complete inertial navigation systems (note in the middle of each triangular ring laser the "dithering" motor).

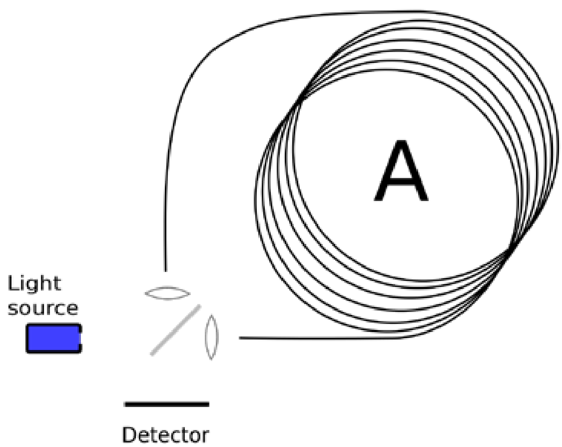


Figure 6. Schematic of a Fibre Optic interferometer. Image credit: D Mcfadden.

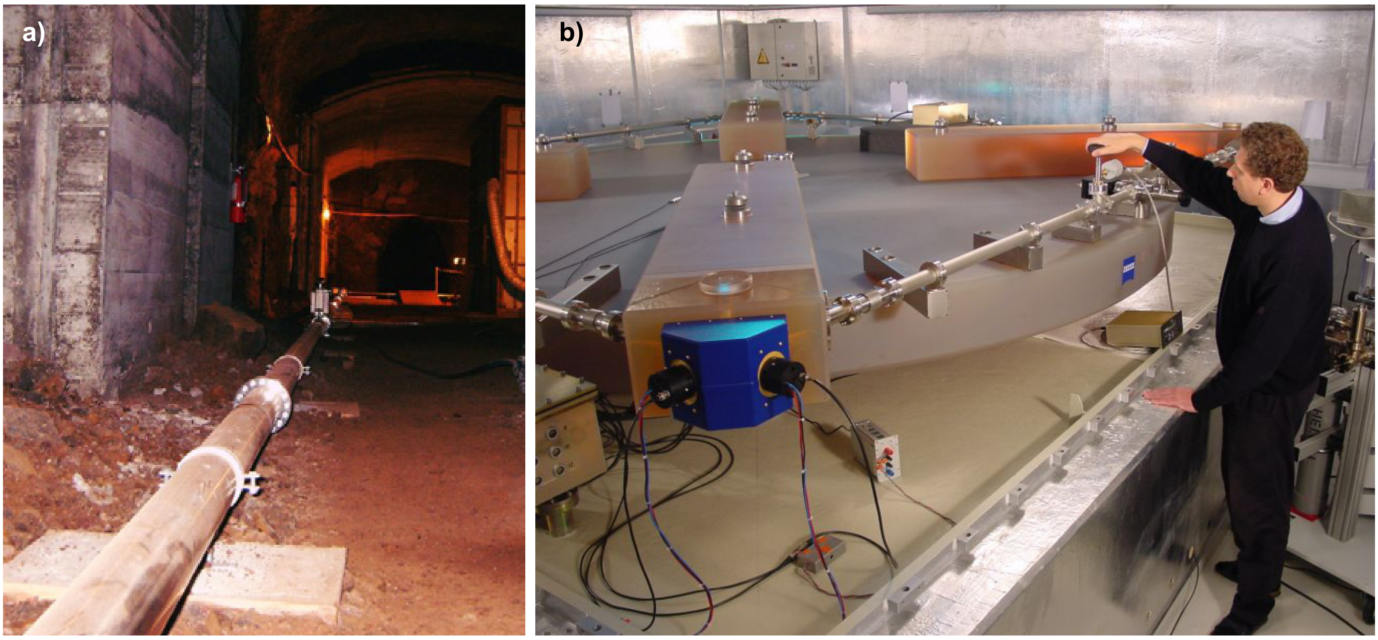


Figure 7. a) The north arm of the University of Canterbury's UG-2 ring laser, situated in the Cashmere Caverns, New Zealand. b) G (for "Grossring") Ring Laser in Bavaria, Germany. Both are situated underground to give thermal stability.

effects came to be investigated in detail such as the precession of the equinoxes, the Earth's Eulerian wobble - a consequence of the departure from its spherical shape - changes in the length of the day (measured in fractions of a millisecond per day) and so forth [7].

Ironically, the great earthquake of September 2010, and its aftershocks, that caused devastation in Christchurch were accurately documented by the underground interferometers and caused some damage at the installation in the cave, but the work continues, there and in Germany and elsewhere, with the aim of improving sensitivity to the point of being able to detect fundamental physical effects, e.g. General Relativistic precessions of the rotating Earth, such as the Lense-Thiring effect. But basically, these large ring lasers may be regarded as components of an inertial navigation system for 'spaceship Earth'.

References

[1] G Sagnac, *"Éffet tourbillonnaire optique. La circulation de L'Éther lumineux dans un interférographe tournant"*, J. de phys. et le radium, 5, **4**, 177–195, (1914).

[2] Albert A Michelson, Henry G Gale, *"The Effect of the Earths Rotation on the Velocity of Light, II."*, The Astrophysical Journal, **61**, 140–145, (1925).

[3] EJ Post, *"Sagnac effect"*, Rev. Mod. Phys., **39** (2) 475–493, (1967).

[4] AH Rosenthal, *"Regenerative Circulatory Multiple-Beam Interferometry for the Study of Light-Propagation Effects"*, J. Opt. Soc. Am., **52** (10) 1143–7, (1962).

[5] WM Macek, DTM Davis Jr, *"Rotation rate sensing with traveling-wave ring laser"*, Appl. Phys. Lett., **2** (3) 67–68 (1963).

[6] GE Stedman, HR Bilger, *"Ringlaser, an ultrahigh-resolution detector of optical nonreciprocities"*, Digital Signal Processing, **2** (2) 105–109 (1992).

[7] GE Stedman, *Ring laser tests of fundamental physics and geophysics,* Rep. Progr. Phys., **60,** 615–688 (1997).

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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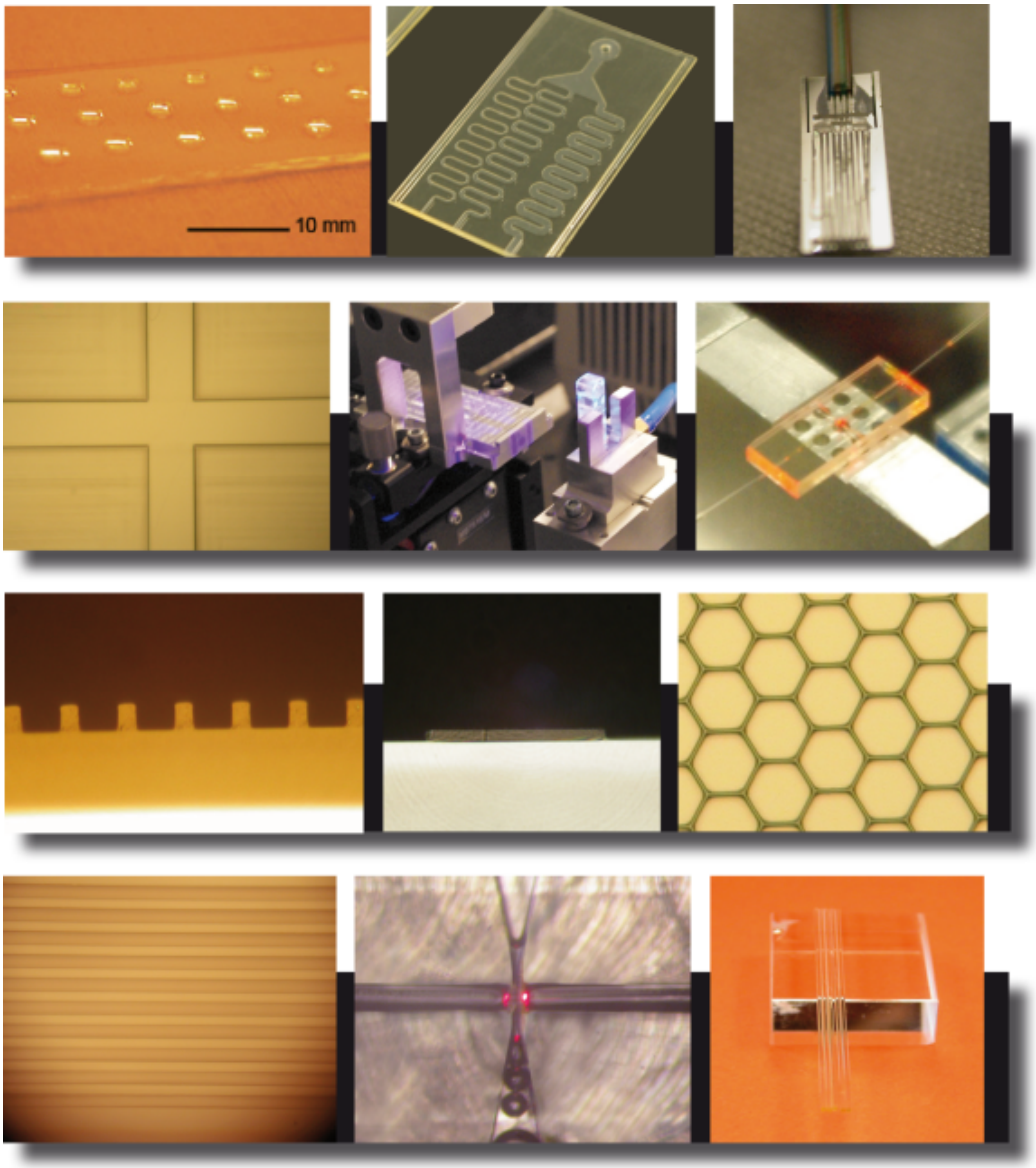

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Bio-Inspired Photonic ZnO Nanomaterials

by Yuanwen Zhang and Ziqi Sun

Biological species in nature have developed very unique structures and functions very close to perfection to suit their specific living environments after millions of years of evolution and selection, which offer us excellent inspiration for developing artificial nanomaterials with extraordinary optical properties. In our group at QUT, we have synthesised ZnO nanostructures based on the biological photonic structures found in fish-scales and fly-eyes, which present superior visible-light response properties.

During millions years of evolution, Nature has developed very unique structures and specialised functions for creatures to suit their specific living circumstances [1]. Fascinating optical phenomena, such as iridescent structural colours, miraculous transparency, and superior light response are produced in different natural structures [2, 3]. Inspired by these interesting properties in natural organisms, researchers have achieved great progress in developing artificial photonic materials with well-designed multiscale photonic structures in recent years [4]. The group led by Dr Ziqi Sun at Queensland University of Technology has made significant progress on developing bio-inspired photonic nanomaterials by learning from fish-scales and fly-eyes [5-7].

Here we describe the designs of bio-inspired ZnO nanostructures by mimicking the natural photonic structures found in the cycloid scales of Asian Arowana (Scleropages) [5] and the compound eyes of horse-flies (Hybomitra micans) [6-7]. ZnO is a typical inorganic metal oxide that is easily fabricated into a variety of morphologies to meet different functional requirements. Our synthetic strategies of ZnO nanostructures are based on the bottom-up assembly of the bio-inspired inorganic nanomaterials from molecules via a recently developed two-step self-assembly approach [8]. In this approach, the P123 surfactant is put into ethanol solvent to form primary lamellar micelles, then the ZnO precursor solution and secondary surfactant, ethylene glycol (EG), are subsequently added into the solution to further assemble the primary structures into desired hierarchically ordered structures during the solvothermal process. The artificial bio-inspired ZnO nanomaterials inherit extraordinary optical properties from these organisms, which are promising for applications in energy harvesting, conversion, and storage devices.

Fish-scale inspired ZnO nanostructures

Camouflage protection is an important function of natural fish scales and enables fish to escape from predators via light reflection and refraction that can hide the fish or allow them to blend into their environment [5]. Figure 1a illustrates an Asian Arowana fish, which are usually ~ 60 cm in length and covered with large cycloid scales, each of which is generally longer than 2 cm. An enlarged image of the scales is shown in Figure 1b. In this study, bio-inspired ZnO nanostructures in the form of isolated microspheres (Figures 1c and d), which have surfaces with a similar stacking sequence to that of the fish scales, were synthesised and grown on high-seed-density substrates via a facile hydrothermal process.

The optical properties of the fish-scale bio-inspired nanostructures coated on high-seed-density substrates were

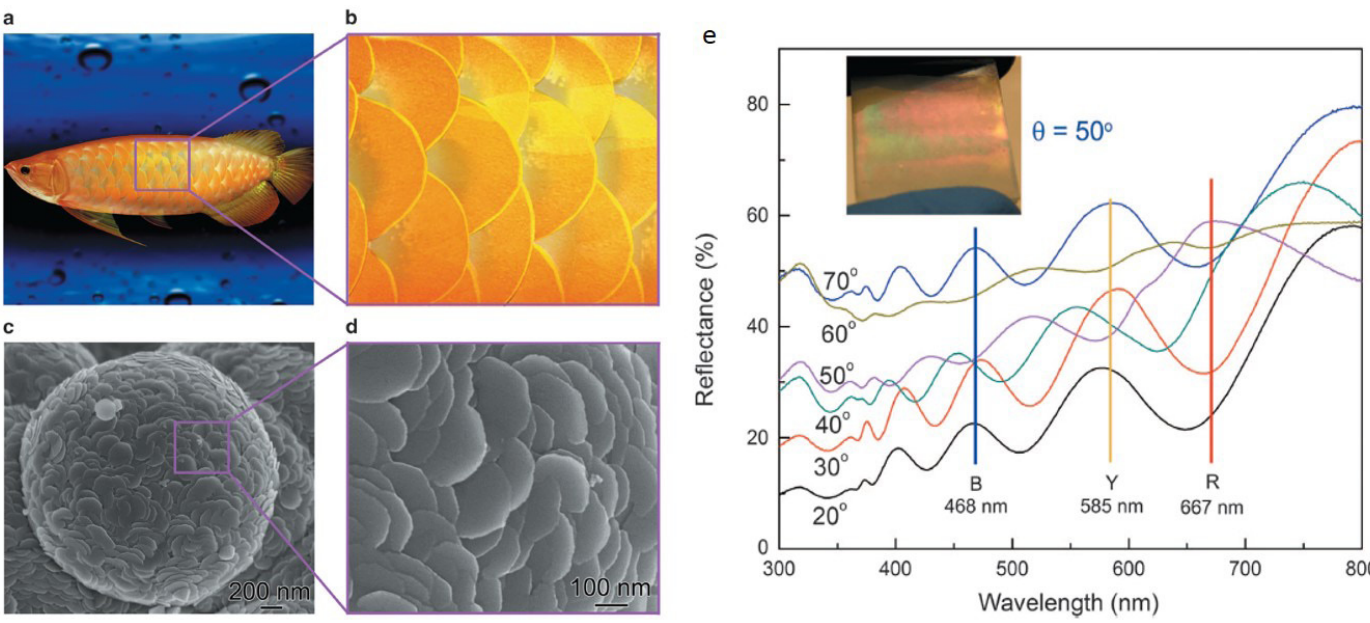

Figure 1 (a) an optical image of an Asian Arowana fish; (b) an enlarged optical image of Asia Arowana fish scales; (c) a scanning electron microscope (SEM) image of ZnO nanostructures; (d) a high-magnification SEM image of ZnO nanostructures; (e) variable-angle reflectance spectra of the bio-inspired nanostructured coatings, the insets are the corresponding optical images with an incident angle of ~ 50° under white light.

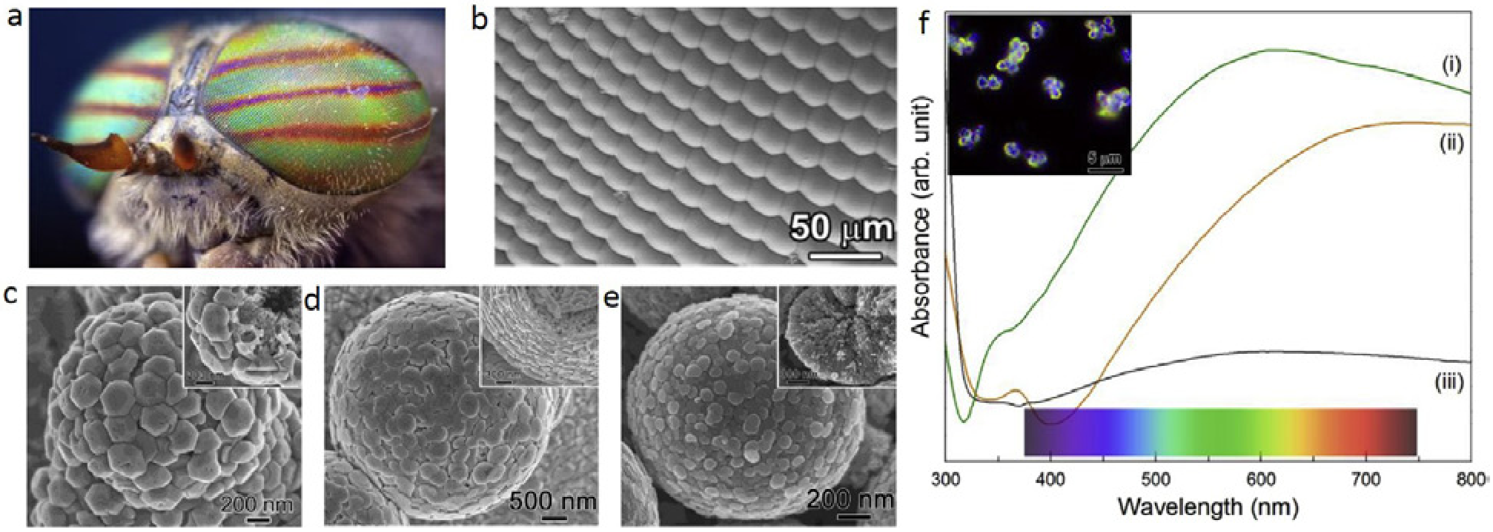

Figure 2. (a) Optical image of the compound eyes of a horse-fly (Hybomitra micans) with brightly coloured patterns under sunlight; (b) microstructure of the surface of the fly compound eye; (c-e) morphologies of the bio-inspired nanostructures with controlled shell structures and nanolenses in the forms of microspheres, the insets shows the cross-sectional images of the microspheres; (f) absorption spectra collected from the compound-eye inspired microspheres, curves (i-iii) are corresponding to the samples in figure (c-e) respectively, the inset displays the optical image of the bio-inspired microspheres under transmitted white light.

examined via a variable-angle specular reflectance system that was installed in an ultraviolet–visible–near-infrared spectrometer. Figure 1e presents reflection spectra and corresponding optical images of the bio-inspired thin films, which show strong refraction and obvious colour variation with different angles tilting to the light source. The bio-inspired coatings present predominantly green colours at 20° and 30° but predominantly red colours at 50° and act like prism arrays as clear rainbow-like strips were observed under white light. The rainbow-like, shimmering iridescence that resulted from the specific hierarchically ordered nanostructures in the fish-scale bio-inspired nanostructures is not only of great scientific interest but also might prove useful in a wide range of applications related to reflective displays, packaging, advertising and solar energy harvesting. The fish-scale bio-inspired nanostructured coatings provide a new way to design thin films or coatings with tuneable optical properties for use in modern optoelectronic devices.

Fly compound-eye inspired ZnO nanostructures

The compound-eye structures found in insects have also attracted considerable attention due to their advantages of a wide field of view, negligible distortion and aberration, high temporal resolution and significantly high low-light photosensitivity [6-7]. Figure 2a shows an optical image of the compound eyes of a horse-fly (Hybomitra micans) which have a wide field of view and high photosensitivity because of the close-packed hexagonal ommatidia that are spherically distributed over a significant portion (Figure 2b). Inspired by this fancy photonic structure, we have fabricated similar structures in the form of hemispherical eye-like nanostructured arrays and different morphologies have been achieved by adjusting the synthetic parameters such as EG proportion, ageing time and synthesis temperature. Figure 2c shows the microspheres with clear three-zone shells composed of an outermost microlens layer, a middle channel structure, and an inner hollow zone, however the microspheres in Figure 2d and Figure 2e present only conical shaped crystals in the shells and rhabdom-like channel structures respectively.

As the nanostructures were inspired by observing biological systems, it is expected that the isolated microspheres will bring us some exciting optical properties. Figure 2f shows the absorption spectra collected on the corresponding compound-eye inspired microspheres in Figure 2c-e. It is interesting that the bio-inspired nanostructures with larger conical lens-like structures presented prominent visible light adsorption except for the edge of blue light, as in curves (i) and (ii) shown in Figure 2f, owing to the multiple light refraction effects aroused by the outermost ZnO crystals, while the bio-inspired microspheres with dominant channel-like structures could not show significant visible absorption because the crystal size is smaller than the critical size (half of the shortest wavelength of visible light, 190 nm) for arousing a significant visible light response. The inset of Figure 2f displays a dark-field optical image of the ZnO bio-inspired microspheres under transmitted white light. The blue colour of the bio-inspired microspheres confirms that the ZnO nanostructures have strong visible light absorption except for the blue-edge. The low solar energy harvesting and conversion efficiency has become a major problem in solar energy science and engineering. This bio-inspired design of materials with enhanced visible-light absorption will make it possible to capture energy across the wide solar spectrum with a single semiconductor material and thus conquer this major challenge.

Summary

Based on mimicking the structures of and thus achieving similar functionalities to the targeted biological systems, fish-scale and fly-eye inspired ZnO nanostructures with extraordinary visible-light response properties have been achieved via facile self-assembly approaches. High visible light responses allow high reactivity of the semiconductors so that they can take advantage of the main part of the solar spectrum. Economically viable and stable energy harvesting conversion devices with efficiencies surpassing those presently available require a new generation of materials offering broad-spectrum light harvesting properties. Therefore, the unique optical properties of the bio-inspired nanostructures will open up a new way to design wide-range visible light responsive devices.

References
[1] P Vukusic, JR Sambles, Nature **424**, 752 (2003)
[2] S Kinoshita, S Yoshioka, Chem Phys Chem **6**, 1442 (2015)
[3] RO Prum, J Exp Biol 209, 748 (2006)
[4] L Wu, et al., Adv Opt Mater **4**, 195 (2016)
[5] Z Sun et al., NPG Asia Mater **7**, e232 (2015)
[6] Z Sun, et al., Small **10**, 3001 (2014)
[7] Z Sun et al., Mater Today Chem **1**, 84 (2016).
[8] Q Liu, Z Sun, et al., J Mater Chem A **3**, 11688 (2015)

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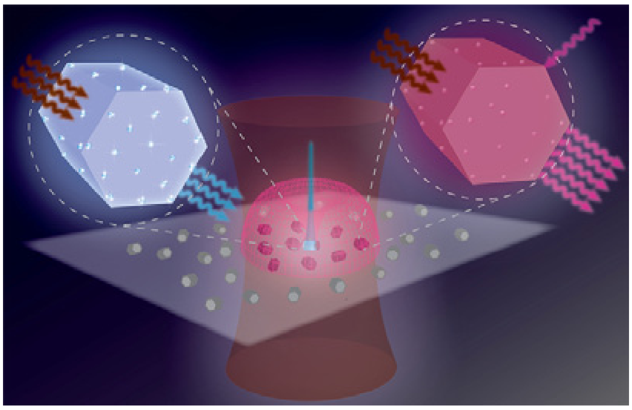
Australian Research in the News

New nanoparticle discovery to aid super-resolution imaging

Researchers at the ARC Centre of Excellence for Nanoscale BioPhotonics (CNBP), Macquarie University, the University of Technology Sydney (UTS), Peking University and Shanghai Jiaotong University have made a breakthrough in the development of practical super-resolution optical microscopy, beating the diffraction limit and paving the way for the detailed study of live cells and organisms, on a scale 10 times smaller than can currently be achieved with conventional microscopy.



A nanoparticle gives off luminescence (top left), whereas the luminescence of other excited nanoparticles (e.g. top right) is switched off by the low-power infrared laser (shown as a semi-sphere in the centre of the image). Image courtesy of Xianlin Zheng, CNBP/cnbp.org.au.

Reported in Nature, the international team of researchers has demonstrated that bright luminescent nanoparticles can be switched on and off using a low-power infrared laser beam, and used to achieve images with a super resolution of 28nm. The technique uses lanthanide-doped upconversion nanoparticles (UCNPs) to improve the efficiency of stimulated emission depletion (STED) microscopy, so that lower levels of illumination can be used.

Professor Jim Piper, leader of the research team at Macquarie University and the ARC Centre of Excellence for Nanoscale BioPhotonics (CNBP), sees these nanoparticles as having new unique properties. "These allow researchers to see well beyond normal limits of standard microscopes," Professor Piper said. "It will let you see deeper and more clearly at the cellular and intra-cellular level - where proteins, antibodies and enzymes ultimately run the machinery of life."

Professor Dayong Jin from UTS, a lead researcher on this project, said using a low-powered laser beam solves two problems that currently limit super-resolution imaging for users. "Significantly reducing the power requirement removes the need for bulky and expensive lasers," he said. "The heat generated by high-powered lasers also destroys fragile biological samples, so reducing the power makes it much more biocompatible."

Associate Professor Peng Xi at Peking University, a leading researcher in super-resolution microscopy, and also a Partner Investigator of the CNBP and an Honorary Professor at UTS said, "After the Nobel prize in 2014, the attention of the super-resolution community has been focused on the development of techniques that are live cell compatible. Our newly developed rare-earth nanoparticles decreases the requirement for high power laser by 2-3 orders of magnitude, which enables the wide application of this technology in live cells, and dramatically decreases the cost and complexity of the system."

Source Material: https://www.medianet.com.au/releases/126459/

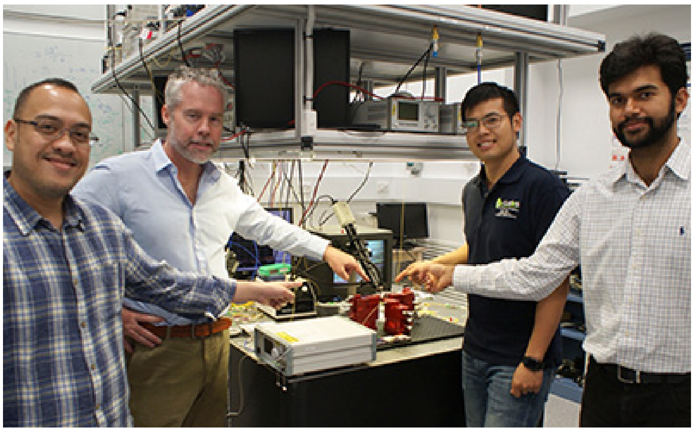
Original article: Y Liu, Y Lu, X Yang, X Zheng, S Wen, F Wang, X Vidal, J Zhao, D Liu, Z Zhou, C Ma, J Zhou, J A Piper, P Xi & D Jin, *Amplified stimulated emission in upconversion nanoparticles for super-resolution nanoscopy*, Nature, **543** 229–233 (2017). DOI:10.1038/nature21366

Photonics breakthrough paving the way for improved wireless communication systems

Researchers from the ARC Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS) in the University of Sydney's Australian Institute for Nanoscale Science and Technology have made a breakthrough achieving radio frequency signal control at sub-nanosecond time scales on a chip-scale optical device, recently published in Optica. CUDOS and School of Physics PhD candidate at the University of Sydney, lead author Yang Liu, said the new research could unlock the bandwidth bottleneck faced by wireless networks worldwide.

"Nowadays, there are 10 billion mobile devices connected to the wireless network (reported by Cisco last year) and all require bandwidth and capacity," Mr Liu said. "By creating very fast tunable delay lines on chip, one eventually can provide broader bandwidth instantaneously to more users. The ability of rapidly controlling RF signal is a crucial performance for applications in both our daily life and defence. For example, to reduce power consumption and maximise reception range for future mobile communications, RF signals need to achieve directional and fast distributions to different cellular users from information centres, instead of spreading signal energy in all directions."

The lack of the high tuning speed in current RF techniques in modern communications and defence, has motivated the development of solutions on a compact optical platform. These optical counterparts had been typically limited in performance by a low tuning speed on the order of milliseconds (1/1000 of a second) offered by on-chip heaters, with side effects of fabrication complexity and power consumption. "To circumvent these problems, we developed a simple technique based on optical control with response time faster than one nanosecond: a billionth of a second – this is a million times faster than thermal heating," said Mr Liu.



David Marpaung, Benjamin Eggleton, Yang Liu and Amol Choudhary inside the Sydney Nanoscience Hub, pointing at a thumbnail-size chip being evaluated in the broadband microwave testbed. Image courtesy of CUDOS.

CUDOS Director and co-author Professor Benjamin Eggleton, who also heads the Nanoscale Photonics Circuits AINST flagship, said the technology would not only be important for building more efficient radars to detect enemy attacks but would also make significant improvements for everyone. "Such a system will be crucial not only to safeguard our defence capabilities, it will also help foster the so-called wireless revolution – where more and more devices are connected to the wireless network," Professor Eggleton said. "This includes the internet of things, fifth generation (5G) communications, and smart home and smart cities. Silicon photonics, the technology that underpins this advance, is progressing very quickly, finding applications in datacentres right now. We expect the applications of this work will happen within a decade in order to provide a solution to the wireless bandwidth problem. We are currently working on the more advanced silicon devices that are highly integrated and can be used in small mobile devices," Professor Eggleton said.

By optically varying the control signal at gigahertz speeds, the time delay of the RF signal can be amplified and switched at the same speed. Mr Liu and fellow researchers Dr Amol Choudhary, Dr David Marpaung and Professor Benjamin Eggleton achieved this on an integrated photonic chip, paving the way towards ultrafast and reconfigurable on-chip RF systems with unmatched advantages in compactness, low power consumption, low fabrication complexity, flexibility and compatibility with existing RF functionalities.

Source material: http://www.cudos.org.au/news/2017-03-31_optica.shtml

Original article: Y Liu, A Choudhary, D Marpaung, and BJ Eggleton, *"Gigahertz optical tuning of an on-chip radio frequency photonic delay line,"* Optica **4**, 418-423 (2017). DOI: 10.1364/OPTICA.4.000418

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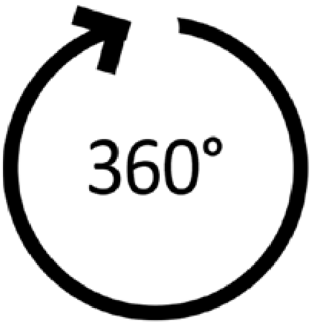

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