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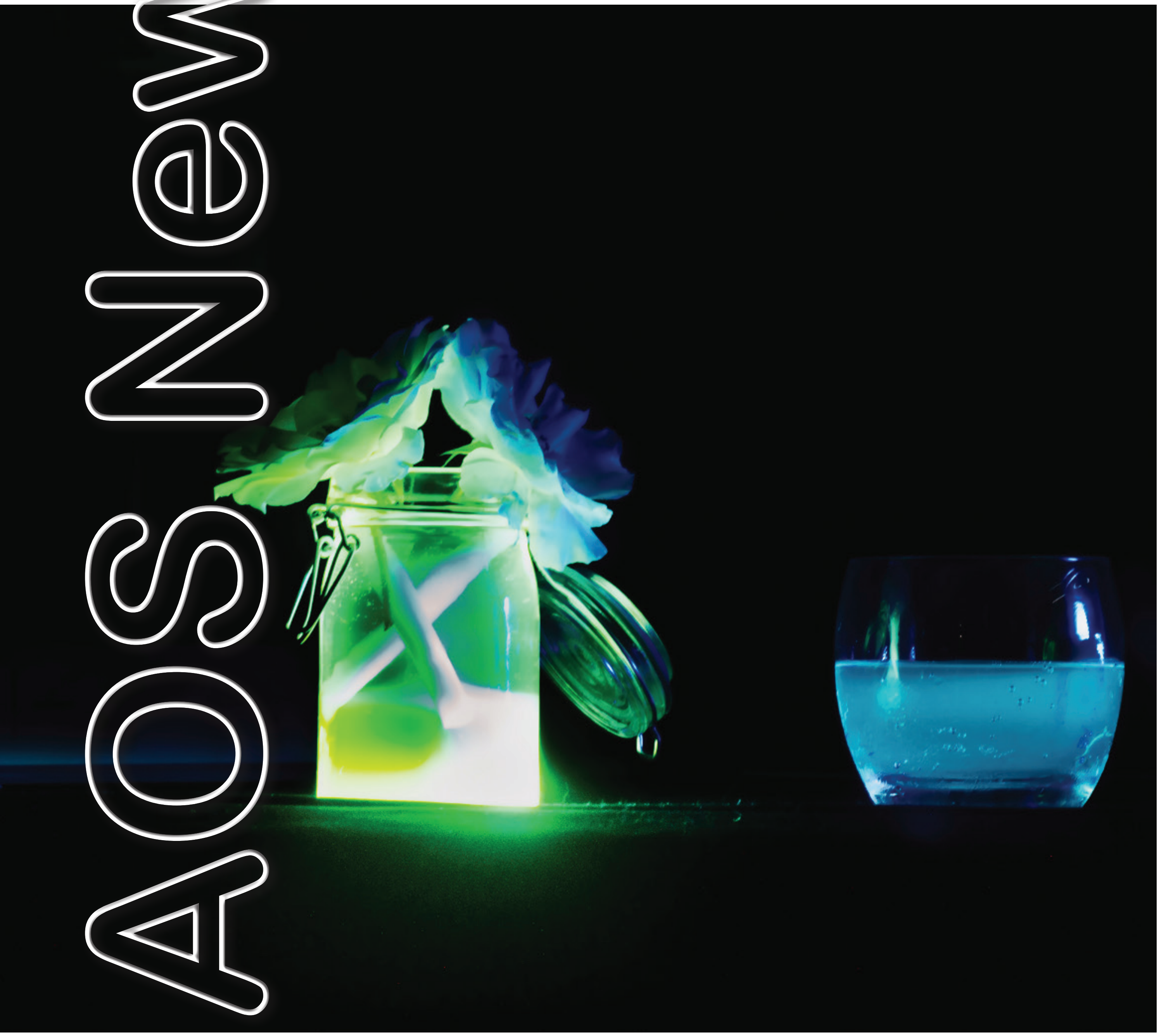
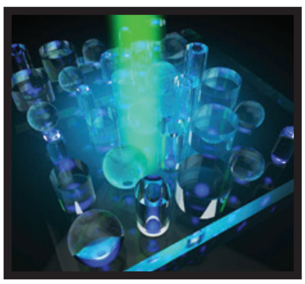


AUSTRALIAN OPTICAL SOCIETY



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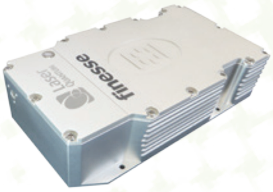

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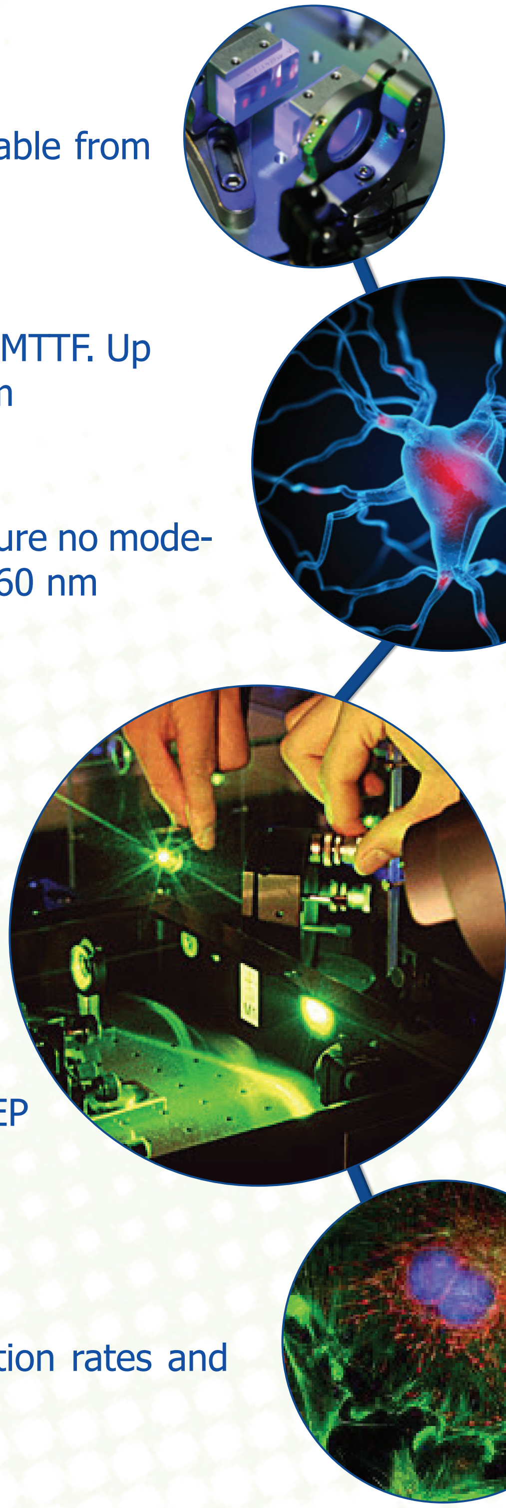
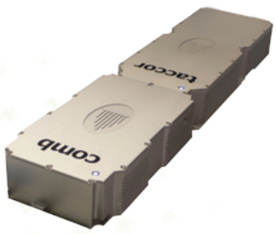


Ultrafast lasers



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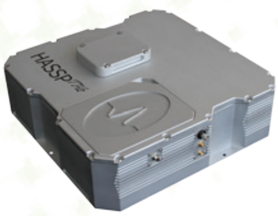

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AOS News is the official news magazine of the Australian Optical Society. Formed in 1983, the Society is a non-profit organisation for the advancement of optics in Australia. Membership is open to all persons contributing to, or interested in, optics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

Submission guidelines

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

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.

PHOTON SCIENTIFIC

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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.
Rates: Colour pages $345, Black and White pages $175, with a surchargee for choosing a specific page for the ads (rates excl. GST). 1-2 Black and White pages in the main body of the newsletter are free to corporate members.

Copy Deadline
Articles for the next issue (July/Aug 2019) should be with the editor no later than 19 July 2019, advertising deadline 12 July 2019.

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Australian Optical Society website:
http://www.optics.org.au

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- ...and more

May 2019 Volume 33 Number 1

Articles

Departments

Cover Pictures:

- The next winner of the AOS photo competition is Krzysztof Maliszewski. A phosphorescence effect is especially spectacular in darkness. The picture presents an experiment set created by University of Auckland SPIE Student Chapter for celebrating the International Day of Light, see page 15.
- Insets (left to right)
  - A light-trails long exposure of London's Tower Bridge, shot on iPhone8Plus using the NightCap app. Smartphones can be used to take high quality photos with the right settings and apps, see page 32.
  - Active, light-emitting nanoscale structures offer unique opportunities for novel types of light sources and nanolasers, with halide perovskites having exceptional optical and electrical properties. Here we see a schematic illustration of the concept of halide-perovskite metasurfaces, see page 28.

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President's Report

There have been significant developments concerning Conferences and the planned Photonics Survey that I would like to report on in this issue of AOS news.

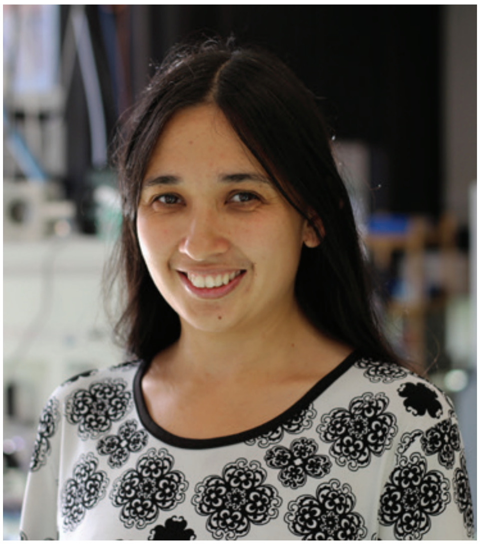
Firstly, as discussed in the previous report, we have arranged to combine our ANZCOP conference this year with the SPIE conference held every two years in Melbourne. These two conferences have always had significant overlap in subject areas, and for different reasons they have always been in December in odd years. It therefore makes good sense to trial the option of collocating the meetings. This option has also enabled us to identify other areas in which both SPIE and AOS have stakeholders, and accordingly the ANZCOP 2019 conference will actually have several collocated subconferences, including Astrophotonics and Biophotonics focused meetings. The overall logistical organisation of the collocated meetings is being handled by SPIE, while the name of the joint meeting is still ANZCOP 2019. The local organisation of these meetings (technical, venue and programming issues), is being handled by Arnan Mitchell in coordination with the Chairs of the individual submeetings. Whilst there will indubitably be problems in accommodating the various aims of AOS and SPIE in welding these two meetings together, Arnan is doing a great job in balancing the various factors that need to be considered.

I would like to emphasise however, that this is a trial arrangement and AOS and SPIE have agreed to review the joint meeting next year. No commitment has been made to combine the meetings in the future. At this stage however, I would like to urge you all to submit papers to whatever subconference is most appropriate. Due to the late publicity we have arranged to extend the submission deadline, and hopefully this will enable as many people to submit and attend as possible. We have also made significant progress in the running of the Photonics Survey which we have been planning for the last two years. Whilst similar surveys started in the USA over a decade ago, the rapid growth of the sector has meant that regular re-assessment of the influence of photonics is vitally important for central planning, although much of the economic impact of these technologies is not immediately apparent. Indeed, the recent 2018 survey in the UK was entitled "UK Photonics: The Hidden Economic Engine". In recent months, similar surveys have been released for the Netherlands, Scotland and for all of Europe. Whilst photonics is undoubtedly not as big a part of our economies, it is similarly hidden, and quantifying its growth and importance is important. We are fortunate to have the assistance of Simon Poole in coordinating the data collection for Australian companies, whilst I am performing a similar exercise in New Zealand. One of the authors of the UK report has been engaged to develop our report, and will be visiting us in July to complete the survey, which we expect to release by September.

Finally I would like to comment on a meeting that I attended in Shenzhen in Early May. The organisers of this meeting (concentrating on laser enabled manufacturing) are keen to promote linkages with the AOS and invited me to Shenzhen to give a talk from our perspective. This enabled me to spend some time exploring the actual mix of the Australian and New Zealand export commodities, which whilst quite different, have the common factor of not being based on manufactured goods. Both countries have however, publicly stated their wish to rebalance this mix to include more high value products. It is my hope that the AOS can assist by promoting the development of photonics based start-up companies, and the interaction of academics with industry. These have always been issues of particular importance to me, and I have seen many hopeful signs recently. I am sure that we can leverage our outstanding research strengths to enable growth in Photonics based enterprises which will contribute to this transformation, and I hope to see more progress during my tenure as President.

John Harvey
AOS president

Editor's Intro



Welcome to another issue of AOS News. Apologies for the delay in this edition coming out – I recently changed jobs and ended up having some computer and software issues that held up completion. We have a selection of articles for you this time including one on active meta-optics with halide perovskites and an item on Sir William Rowan Hamilton and his contributions to optics. There is also information about a new laser system at the Photon Factory in Auckland and a look at the history of women in science writing. Our 'Optics in Everyday Life' section explores smartphone photography. We also have the next winner of our photo competition and details on how to enter. Please send in articles or conference reports if you can as we haven't had many new contributions this year and would love to hear from you.

I read the recently published women in STEM decadal plan released by the Australian Academy of Science and Australian Academy of Technology and Engineering. They highlight the barriers to female participation in science at all education and career stages and set out the reasons that the country would benefit from addressing some of these issues. The report identifies six areas where change can be made and details how this can be done. They hope for support from the government, academia, industry, the education sector and the community to achieve these goals. Their vision is that in 2030 workplaces will be respectful, free of harassment and discrimination and will value diversity. They also make specific mention of people from diverse backgrounds which is good to see as often people look at only one area when suggesting reforms, rather than trying to suggest solutions that can benefit everyone. Intersectionality is becoming much more widely discussed, and it is refreshing to see a plan that aims to include men and mentions all genders being supported. Fair implementation of policies is important if they wish to gain support and it is vital that advances for women don't come at the expense of career progression for men, particularly those from minority backgrounds.

The first of the six areas, or 'opportunities', is leadership and cohesion. The plan was developed in consultation and a recurring theme was the lack of cohesion and small scale of existing programs. The report suggests that for systemic and sustained change to occur this has to be led from the top and requires coordination across the STEM ecosystem. They support the various accreditation programs as a means of accountability, such as the Science in Australia Gender Equity (SAGE) Initiative and WGEA Employer of Choice Gender Equality awards. These show promise, but need careful implementation as there needs to be the option for people to critically analyse problems that exist and suggest solutions rather than for institutions to show themselves in the best light. Women tend to be heavily involved in these reports, carrying the burden of organisations wanting them to pass, spending many extra hours on reporting and data collection, so it is important that they don't end up being penalised for this. The report lists a number of recommendations, including the nationwide rollout of SAGE, introducing diversity measures as a condition of government funding, developing national guidelines for best practice in selection processes and adopting national standards for accreditation bodies. Next they look at evaluation, suggesting establishing a national evaluation framework for STEM gender equity initiatives and improving awareness of existing programs and their efficacy. This would provide performance data for STEM gender equity programs to enable those that work well to be scaled up.

The third area is workplace culture, where they would like to see a shift towards inclusivity and respect and challenging traditional stereotypes as well as increasing flexibility as this can be a major barrier in attracting and retaining women. They also want to have increased opportunities to re-enter the STEM ecosystem for people with career interruptions and develop best practice guidelines for STEM mentoring and leadership programs. Here they specifically mention that plans should consider intersectionality to improve diversity. They also would like to see a change in caring responsibilities so that men take up more of these. The fourth area is visibility and concentrates on the need for role models and steps to be taken to improve representation in leadership positions, conference panels and the media. They warn that many women STEM professionals from under-represented groups feel the need to take part in outreach and public engagement activities, but these efforts are not always recognised or helpful for career progression. Here they also look at conferences and suggest the inclusion of child care or support bursaries and the promotion of women in STEM expert directories.

The fifth area is education where they suggest that extra attention needs to be paid to vocational education and training and students from low socioeconomic, rural and regional areas and those from Aboriginal or Torres Strait Islander backgrounds as they are particularly under-represented. Ensuring that all students understand STEM careers that are possible from an early age and looking at real-world scenarios should help with engagement and motivation in addition to work combatting stereotypes. The final area is industry action where they suggest a framework should be developed to help small and medium enterprises to address gender imbalance.

The report makes a number of suggestions and offers a bold plan to try to increase female participation in STEM. Hopefully some of the ideas can be implemented so that the bright future that is outlined in the report can come to pass.

Jessica Kvansakul
Editor

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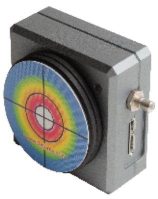

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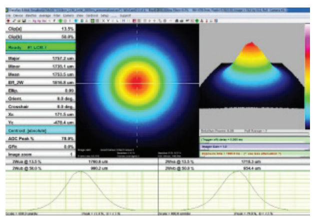

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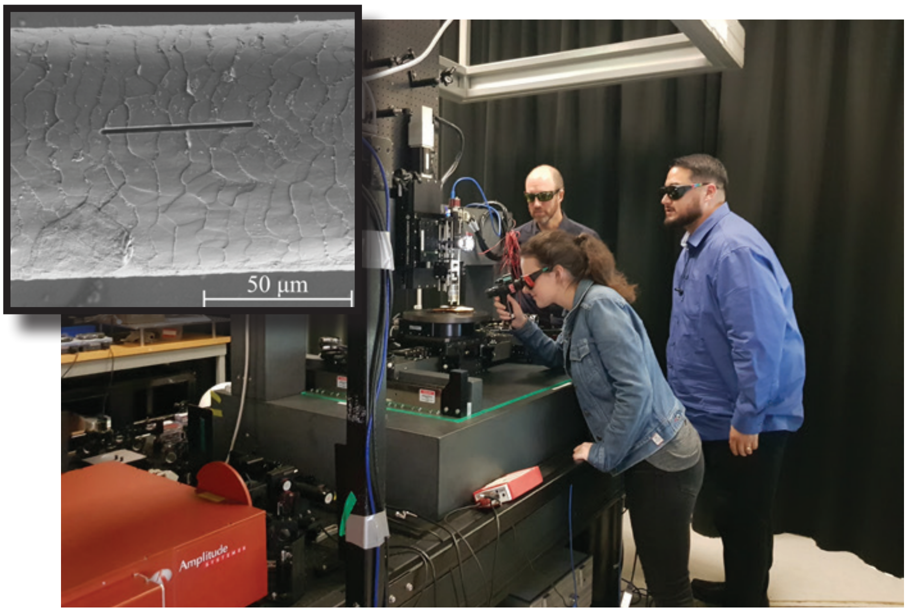
The Photon Factory: Developing Industry Applications With Leading Researchers

by Lexie Henderson-Lancett and Claude Aguergary

The Photon Factory at the University of Auckland, New Zealand, recently installed an Amplitude s-Pulse HP2 laser system from Raymax Applications Pty Ltd in Sydney, extending their already successful facilities. The Photon Factory is an award-winning research facility led by Professor Cather Simpson with a mission to achieve the extraordinary using state-of-the-art laser photonic technology to explore the use of light for energy, health, research in Physics and Chemistry, and for advanced technology. The new Amplitude Systemes' s-Pulse compact femtosecond amplifier sets new standards featuring superior optical performance, such as a short pulse duration, a high repetition rate, and an excellent beam quality for optimal focus. Suitable for a lab environment the Amplitude laser boasts ease of use in the category of ultrafast lasers.



Photon Factory student and staff performing micro-machining on a silicon wafer using the Amplitude laser coupled to a micromachining stage with nanometre precision. (Inset: 1.8 µm wide, 50 µm long cut performed on a human hair).

As part of the Faculty of Science at the University of Auckland, some 46 scientists and students from a range of disciplines including engineering, physics, chemistry and even biology work on a range of projects, at times sharing their skills and knowledge to support project development. A key aim of the Factory's fundamental discoveries is to see these applied in New Zealand industry and beyond or through spin-off companies.

The new Amplitude s-Pulse HP2 laser system will be used in conjunction with Aerotech positioning stages for surface texturing and precise machining of virtually any material from nanometre to centimetre scale. Typical applications focus on the alteration of the wettability properties of a material to create super-hydrophobic or super-hydrophilic surfaces, nano-pore drilling, or surface texturing to reduce bacterial growth.

Chemical Sciences is another significant part of the Photon Factory's activities. Some of their research projects to date in this field have examined the fading rates of red pigments in paintings by the old masters, or the ability of molecules to convert light into more useful forms of energy and how molecules direct the energy acquired in light absorption, and "choose" among potential paths - electron transfer, mechanical motion, bond breaking and forming, fluorescence, vibrational energy dissipation, etc. The focus of another study was on solar energy harvesting complexes, to better understand the relationship between the structure of the complex and the lifetime of the charge-separated state, so that the practical, commercial potential of these types of systems for renewable energy harvesting can be realised.

Collaborative research in the medical field saw a team of students and staff explore the use of ultrashort pulses for lasers for orthopaedic surgeries. Such lasers are used in surgical theatres for their ability to perform clean cuts and reduce bleeding, but are at times incompatible with hard tissues such as bones. Using the latest advances in ultrashort pulsed laser beam shaping, the team at the Photon Factory demonstrated significant improvement in the ablation rate in cortical bones, closing part of the gap with current mechanical tools. This research was done in collaboration with Intuitive Surgical, the global leader in robotically-assisted, minimally invasive surgery. Following the initial laser ablation demonstration, the team is now focusing on the development of a laser system capable of delivering such high-energy femtosecond pulses to the target in a compact and robust all-fibre architecture format. The very promising results yielded by the team may provide a tool for Intuitive Surgical to achieve better surgical results. "This is just one example where the team has worked with a company to advance the capability of their technology," explained Dr Claude Aguergaray, Senior Research Fellow, "With the addition of the Amplitude laser we will have access to a wider parameter space and we hope to explore more projects that will lead to industry uptake of our research outcomes. The Photon Factory has had unheralded success in collaborating with industry and we'd like to see that continue - on a grand scale!" he added.

To investigate opportunities available to work collaboratively with the Photon Factory contact them on:
c.aguergaray@auckland.ac.nz
www.photonfactory.auckland.ac.nz
www.raymax.com.au

Lexie Henderson-Lancett is with Raymax Lasers, Warriewood, NSW. Claude Aguergaray is with the Photon Factory, Faculty of Science, University of Auckland.

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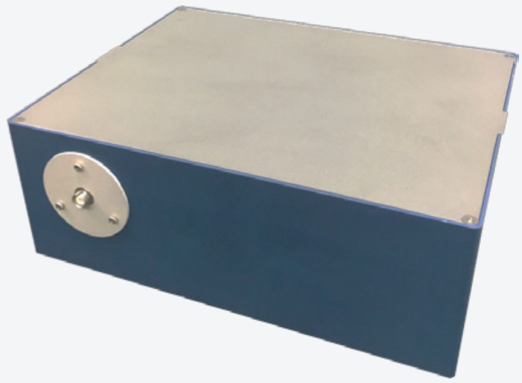

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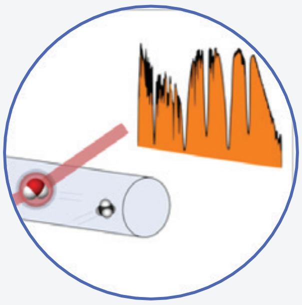

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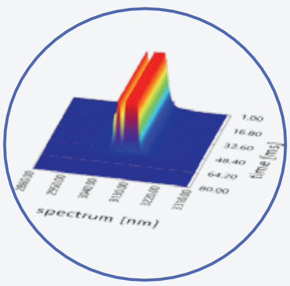

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News

RMIT Distinguished Professor Min Gu wins SPIE Dennis Gabor Award

AOS member, and 2011 Beattie Steel medallist, Professor Min Gu from RMIT University has been awarded the 2019 SPIE Dennis Gabor Award in recognition of his pioneering work in nanoscale information optics. Internationally renowned for his expertise in 3D optical imaging theory, his discoveries are helping drive the development of solutions to some of our biggest challenges in renewable energy, information technology and big data storage. Congratulations Min!

Min Gu is Associate Deputy Vice-Chancellor for Research Innovation and Entrepreneurship and director the Laboratory of Artificial-Intelligence Nanophotonics at RMIT. His research has led to major advancements in how data is stored, displayed and transmitted. This work has also radically decreased the amount of energy needed when it comes to using data, potentially unlocking major environmental benefits.

Recent breakthroughs include:

- groundbreaking new technology to allow super-fast internet by harnessing twisted light beams to carry more data and process it faster
- a new type of high-capacity optical disk that can hold data securely for more than 600 years, offering a cost-efficient and sustainable solution to the global data storage problem
- the world's thinnest hologram, paving the way towards the integration of 3D holography into everyday electronics like smart phones, computers and TVs
- a prototype electrode inspired by an American fern, that could boost the capacity of existing integrable storage technologies by 3000 per cent

Gu said he was honoured to receive the Dennis Gabor Award, and accept it on behalf of his entire research team. "Optics is a tremendously exciting field and nanophonotics is at the frontier of research in so many ways," he said. "Our work is driven by a desire to deliver real solutions to the real issues faced by industry and the community in conjunction with artificial intelligence. We seek industry input from the very start, to deeply understand the challenges and develop tailored technological solutions that can have a genuine impact, so it's wonderful to receive this international recognition for our research."

Min Gu gained a PhD degree in optics from the Chinese Academy of Sciences, before moving to Australia in 1988. Recognised for his pioneering work in nanoscale information optics, Gu is a leading authority in the fields of nanophotonics, nanofabrication and biophotonics. His research has led a new paradigm-shift in nanometric ultrathin wide-angle 3D display and Petabyte data storage. The Dennis Gabor Award is presented annually by SPIE, in recognition of outstanding accomplishments in diffractive wave front technologies, especially those that further the development of holography and metrology applications. The award will be presented to Gu at an official ceremony in August this year in San Diego, California.

It is the latest in a striking list of achievements for Gu, who is a recipient of the W. H. Steel Prize (Australian Optical Society, 2011), the Ian Wark Medal and Lecture (Australian Academy of Science, 2014), the Boas Medal (Australian Institute of Physics, 2015), and the Victoria Prize for Science and Innovation in Physical Sciences (2016). He is also the awardee of the Chang Jiang Chair Professorship and has received an Einstein Professorship Award from the Chinese Academy of Sciences. An elected Fellow of the Australian Academy of Science and the Australian Academy of Technology and Engineering, Gu is also a Foreign Fellow of the Chinese Academy of Engineering.

Source material: https://www.rmit.edu.au/news/all-news/2019/jan/optics-award-pioneering-physicist

Dr Jacqui Romero selected as a L'Oréal International Rising Talent

Australian quantum physicist and AOS member Dr Jacqui Romero from EQUS and the University of Queensland has been selected as a L'Oréal International Rising Talent. The L'Oréal-UNESCO For Women in Science program International Rising Talents are presented to fifteen promising young women, from each world region (Africa and the Arab States, Asia-Pacific, Europe, Latin America and North America). The International Rising Talents are already making significant contributions in their disciplines and are highlighted as future game changers in science. Dr Romero received €15,000 in prize money for her outstanding contributions to advances in science. The award was presented at a ceremony in March at UNESCO's headquarters in Paris.

Dr Jacq Romero is a physicist working in the field of quantum physics, which explains the nature and behaviour of matter and energy at the atomic and subatomic level. In particular, she is exploring how an infinite number of possible shapes of photons can be used to encode information at a higher capacity. Ultimately, this could lead to reliably secure communication, help conserve data privacy and guard against the growing risk of cyberattacks, and deliver more powerful computation.

Her journey to push the boundaries of quantum information began in the Philippines, where she was encouraged by her school teachers to pursue science, even participating in national physics competitions. "It was just beautiful to me, how the rules of physics can describe the natural world so powerfully," she recalls. "I enjoy the creative and problem solving process. The fun I have is really the reward!" At university, Dr Jacq Romero joined an established optics research group, before identifying an opportunity to pursue an experimental quantum physics PhD at the University of Glasgow.

As part of a minority of women in quantum science, she believes improving the representation of women in science requires a fundamental cultural change, starting at school, where girls' and boys' sense of wonder and curiosity should be equally nurtured. In addition to mentorship, strong female role models at every stage of the scientific career path would send positive signals to aspiring women scientists, she suggests. Importantly, inclusivity and gender diversity should be framed in the context of productivity, with leaders creating the supportive environment that would help women scientists return to peak professional performance after having a child.

"Winning a L'Oréal-UNESCO FWIS fellowship has given me a national platform to show that women, particularly mothers, can succeed in science," she concludes. "People are inspired by stories and I think my journey is a story that could do so much to inspire young girls and young women scientists." If science could achieve anything, Dr Jacq Romero would like to see scientific research help solve the major social inequalities that exist in our world.

Source material: https://equs.org/news/dr-jacqui-romero-rising-talent

Conferences

7-12 July 2019, ICAVS

The 10th meeting of the International Conference on Advanced Vibrational Spectroscopy (ICAVS) will take place in Auckland, New Zealand, from 7 to 12 July 2019. This conference series brings together the best and brightest in the research fields of IR and Raman spectroscopy and associated disciplines with leading industrialist, clinicians, and other users of vibrational spectroscopy. The ICAVS tradition supports a vibrant exhibition of commercial instruments, and component suppliers representing leading products in the IR (THz, mid, and NIR), Raman, and laser spectroscopy fields. www.icavs.org/2019-conference

2-4 December 2019, ACLD

The 9th Australian Conference on Laser Diagnostics (ACLD) will be held in Glenelg, a vibrant seaside of Adelaide, from 2 to 4 December. The conference builds on a series of successful meetings since the first Sydney conference in 1996. The conference aims to bring together Australian and international researchers to discuss the development and applications of laser diagnostic techniques. www.acld.org.au

2-6 December 2019, KOALA

The 12th Konference on Optics, Atoms and Laser Applications (KOALA) will be held at the University of Otago from 2 to 6 December. KOALA, a conference for students, run by students, was founded in 2008 by PhD students at the University of Queensland, Brisbane. They were inspired by the success of the Young Atom Opticians (YAO) meetings in Europe and thought it would be great to start a similar student-run meeting in Australasia. The conference has been held annually ever since, and quickly grew in size and reputation. Previous KOALA conferences have showcased student research in a wide range of areas from astrophotonics to biomedical imaging, quantum optics, solid-state physics and more. We welcome research from these topics and any other related field! ionskoala.osahost.org

8-12 December 2019, ANZCOP

The Australian and New Zealand Conferences on Optics and Photonics (ANZCOP) 2019 will be held in Melbourne from 8 to 12 December. This co-locates several SPIE conferences together with the 44th ACOFT, ACOLS and the AOS Conference with a central theme of optics and photonics. The ANZCOP conferences will connect people across all scientific disciplines associated with optics and photonics, incorporating general streams on optical science and technology and focused topical conferences on micro- and nano-materials and devices, biomedical photonics, and astronomical instrumentation. spie.org/conferences-and-exhibitions/anzcop

2-6 August 2020, CLEO-PR 2020

The 14th Pacific Rim Conference on Lasers and Electro-Optics (CLEO Pacific Rim, CLEO-PR 2020) will be held at the International Convention Centre, Sydney, Australia from 2 to 6 August 2020. The Conference will cover all major areas in lasers and optoelectronics along with tutorial sessions, invited sessions and workshops in areas of current interest. The organising committee invites you to join us in Sydney in 2020. We look forward to seeing you there. www.cleopr2020.org

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AOS Photo Competition

Help us demonstrate the beauty of optics and photonics.

Please submit photographs that capture some aspects of optics and photonics, and are aesthetically pleasing. They can, for instance, be of your research, of optical phenomena, of optical devices.

We want your assistance in generating photographs that we can use to promote Australian and New Zealand optics and photonics in print and online. We will publish the best photograph on the front cover of AOS News, and whoever submits this will get a year's membership free.

AUSTRALIAN OPTICAL SOCIETY

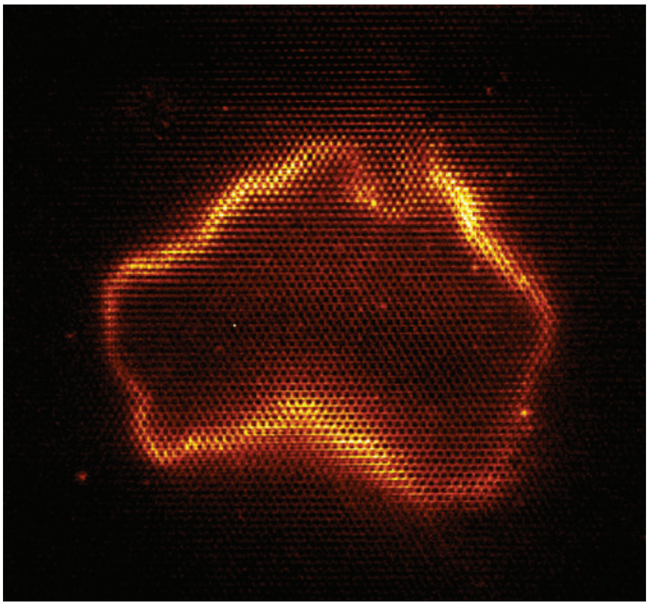
To enter, you need to send to ausoptsoc@gmail.com:

1) The photograph (see required specifications below)
2) Your name and organisation
3) A brief (one or two sentence) description of the photo
4) A covering email, that states "I ____full_name____ took this photograph and own the copyright. I hereby provide a royalty-free, perpetual, non-exclusive license to the Australian Optical Society to reproduce this photograph in print, online or other format."

The photos will be judged by a panel including three AOS Councillors, the Editor of the AOS News and the AOS Webmaster.

The competition will continue on a quarterly basis with judging for each issue of AOS News. AOS reserves the right to carry forward good entries from one quarter to the next, and in any particular quarter to award multiple winners or to award no winner. The competition will initially run until end of 2019. AOS may extend this date or terminate earlier, advising by email, through AOS News, or other reasonable communication.

Queries to ausoptsoc@gmail.com



Our past winners are pictured here. Top: Topological Australia, by Sergey Kruk, Australian National University, shows a photograph of an optical topological state shaped into an Australian continent. Bottom left: Ice bow by Stephane Coen, University of Auckland, shows a 22-degree halo around the sun, caused by high altitude ice crystals. Bottom right: A phosphorescence effect is especially spectacular in darkness. The picture presents an experiment set created by University of Auckland SPIE Student Chapter for celebrating the International Day of Light. By Krzysztof Maliszewski.

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A Brief History of Science Writing Shows the Rise of the Female Voice

by Robyn Arianrhod

This article was originally published on THE CONVERSATION

Three centuries ago, when modern science was in its infancy, the gender disparity in education was not a gap but an abyss: few girls had any decent schooling at all. The emerging new science was clearly a male enterprise. But it arose from a sense of curiosity, and women, too, are curious. If you look closely enough, it's clear women played an important role, as both readers and authors, in the history of science writing.

New vs old ideas

Both science and science writing were up for grabs in the 17th century. Technology was rudimentary and researchers struggled to obtain even the simplest observational evidence, and then searched for ways to make sense of it.

You can see this struggle in the Italian astronomer Galileo Galilei's famous Dialogues of 1632 and 1638. He painstakingly and somewhat tortuously tries to justify his arguments for heliocentrism – in which the planets go around the Sun – and the nature of motion and gravity. Tortuously, not only because he was bending over backwards to please the censors – heliocentrism was held to defy scripture – but especially because most of the experiments, methods, and even the mathematical symbolism of modern science did not yet exist.

So although yesteryear's scientific content was simple compared with today's overwhelming complexity, Galileo's Dialogues show that the lack of data, methods and scientific language presented its own problems for science communication.

Galileo Galilei (1564-1642).

Conversation in science

Galileo resorted to the Socratic device of a conversation, in which he debated his ideas in a long dialogue between an innovative philosopher, Salviati, and two (male) friends.

In trying to convince even the least scientifically learned of his interlocutors, Galileo was writing what we might call popular science (although the more complex parts of the 1638 Dialogue read more like a textbook).

There were no scientific journals then, and there wasn't quite the same distinction between the announcement of scientific discoveries to colleagues and the communication of those ideas to a wider public.

Perhaps the first mass-market popular science book was another dialogue related to heliocentrism, Frenchman Bernard le Bovier de Fontenelle's 1686 Conversations on the Plurality of Worlds.

It was a runaway success that helped non-specialists accept the Copernican system – a Sun-centred solar system – rather than the time-honoured, seemingly self-evident geocentric one with Earth at the centre.

The hero of Fontenelle's story, too, is a male philosopher – but this time he is conversing with a pretty marquise, who is spirited and quick to grasp new facts. Although its style was flirtatious, Fontenelle's book was a significant recognition that women are curious and intelligent.

Isaac Newton (1643-1727).

Science gets complex

Then, the very next year, everything changed. The English physicist and mathematician Isaac Newton published his monumental Principia Mathematica. Suddenly science became a whole lot more complex.

For instance, Fontenelle's explanation of the cause of heliocentrism had been based on Frenchman René Descartes' notion that the planets were swept around the Sun by gargantuan cosmic ethereal vortices.

Newton replaced this influential but unproven idea with his predictive theory of gravity, and of motion in general, which he developed in 500 dense pages of axioms, observational evidence, and a heap of mathematics.

Principia provided the modern blueprint for experimentally based, quantitative, testable theories – and it showed the fundamental role of mathematics in the language of physics.

The trouble was that only the best mathematicians could understand it. It was so innovative (and tortuous in its own way) that some of the greatest of Newton's peers were sceptical, and it took many decades for his theory of gravity to become universally accepted in Europe. Science writers played a key role in this process.

Something 'for ladies'

The earliest popularisations of Newton's work were short or semi-technical, such as that by the French mathematician Pierre-Louis Moreau Maupertuis.

In the 1730s, Maupertuis tutored a real-life marquise, Émilie du Châtelet, but she was of a very different calibre from Fontenelle's fictional student – or indeed the curious but rather flighty marquise in another mass market popularisation: the Italian Francesco Algarotti's Newtonianism for "the ladies".

Newtonianism here referred not just to Newton's theory of gravity. As its somewhat patronising title might suggest, it focused mostly on his more accessible 1704 work, Opticks, which explains his experiments on the behaviour of light and the nature of colour. But these, too, were controversial, and Algarotti was an expert in optics.

He had been inspired to address "the ladies" by two outstanding female contemporaries: his French mathematical friend Émilie du Châtelet, and the Italian physicist Laura Bassi. But both women disliked his book's flirtatious style.

Du Châtelet and her lover Voltaire were writing their own more serious (and non-gendered) popularisation of Newton's work. Du Châtelet later wrote a very successful popular synthesis of the scientific ideas of Newton and his German rival Gottfried Wilhelm Leibniz – Bassi used the Italian translation of it in her own teaching.

Du Châtelet then went on to produce the first translation of Principia outside Britain – an insightful work that is also interesting in the context of popular science writing. She appended a 110-page commentary, summarising Newton's method in everyday language, and explaining more recent applications of his theory.

Émilie Du Châtelet (1706-1749).

The self-taught science writers

Nearly a century later, the Scottish mathematician Mary Somerville felt the same compulsion to reach out to the non-specialist reader – male and female – in the introduction to her book explaining the latest developments of Newton's theory, Mechanism of the Heavens.

It is worth celebrating the fact that Somerville's Mechanism was used at Cambridge as an advanced textbook in celestial mechanics – and at a time when women were not allowed to attend university.

Like Du Châtelet, Somerville was mostly self-taught. She understood the importance of science writing in educating the public, especially those denied formal education, and went on to write two best-selling popular science books: On the Connexion of the Physical Sciences and Physical Geography.

Another successful British female science writer in the early 19th century was Jane Marcet. Unlike those of Du Châtelet and Somerville, Marcet's two books – Conversations on Chemistry and Conversations on Natural Philosophy – were aimed particularly at women.

They were built around conversations between two teenage girls and their female teacher. Unlike Fontenelle's and Algarotti's works for "the ladies", these books were down-to-earth, non-patronising attempts to educate women in practical chemistry and physics.

But like those of Fontenelle and Algarotti, Marcet's books proved popular with male lay readers, too – including the self-taught British physicist and chemist Michael Faraday, who went on to become co-discoverer of electromagnetism.

Biology was also progressing in the 19th century, but this had a downside for women. The discovery that women had smaller brains was used to reinforce the stereotype that women were incapable of intellectual study.

Somerville wrote movingly on how this affected her life. She would have been thrilled to read this year's book by female neuroscientist Gina Rippon, The Gendered Brain, which asserts that brain plasticity and connectivity should displace old notions of gendered brains.

Mary Somerville (1780-1872) was largely self-taught in science.

Rippon's is one of a growing number of female-authored popular science books on all aspects of science, and it is also an example of how women can contribute important new perspectives to scientific topics.

Another example is the ecological perspective of pioneering biologist and science writer Rachel Carson, whose 1962 Silent Spring played a leading role in launching the modern environmental movement.

Scientific understanding is often driven initially by a reductionist approach, and Carson was the first to clearly point out the role of artificial pesticides on the whole food chain.

Then there's the question of ethics in science. Rebecca Skloot's 2010 book The Immortal Life of Henrietta Lacks tells the little-known story of the 1951 illegal harvesting and selling of cells from poor black farmer Henrietta Lacks.

Having diverse voices of all kinds in science and science writing is a good thing for science, as even a brief look at history shows. As far as women's participation goes, we've come a long way. But we still need more women to help shape and tell the story of science

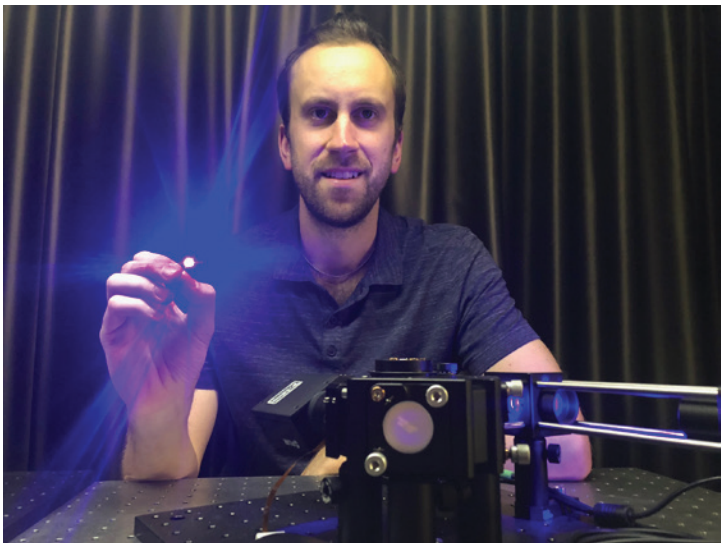
Robyn Arianrhod is with the School of Mathematical Sciences, Monash University.

The original article can be found at: https://theconversation.com/a-brief-history-of-science-writing-shows-the-rise-of-the-female-voice-112701

Australasian Research in the News

3D optical biopsies within reach thanks to advance in light field technology

Researchers have shown that existing optical fibre technology could be used to produce microscopic 3D images of tissue inside the body, paving the way towards 3D optical biopsies. Unlike normal biopsies where tissue is harvested and sent off to a lab for analysis, optical biopsies enable clinicians to examine living tissue within the body in real-time. This minimally-invasive approach uses ultra-thin microendoscopes to peer inside the body for diagnosis or during surgery, but normally produces only two-dimensional images. Research led by RMIT University in Melbourne has now revealed the 3D potential of the existing microendoscope technology.



Dr Antony Orth holding an ultra-thin microendoscope used in the study, which revealed the 3D imaging potential of the existing technology. Image credit: RMIT.

Published in Science Advances, the development is a crucial first step towards 3D optical biopsies, to improve diagnosis and precision surgery. Lead author Dr Antony Orth said the new technique uses a light field imaging approach to produce microscopic images in stereo vision, similar to the 3D movies that you watch wearing 3D glasses. "Stereo vision is the natural format for human vision, where we look at an object from two different viewpoints and process these in our brains to perceive depth," said Orth, a Research Fellow in the RMIT node of the ARC Centre of Excellence for Nanoscale BioPhotonics (CNBP).

"We've shown it's possible to do something similar with the thousands of tiny optical fibres in a microendoscope. It turns out these optical fibres naturally capture images from multiple perspectives, giving us depth perception at the microscale. Our approach can process all those microscopic images and combine the viewpoints to deliver a depth-rendered visualisation of the tissue being examined - an image in three dimensions."

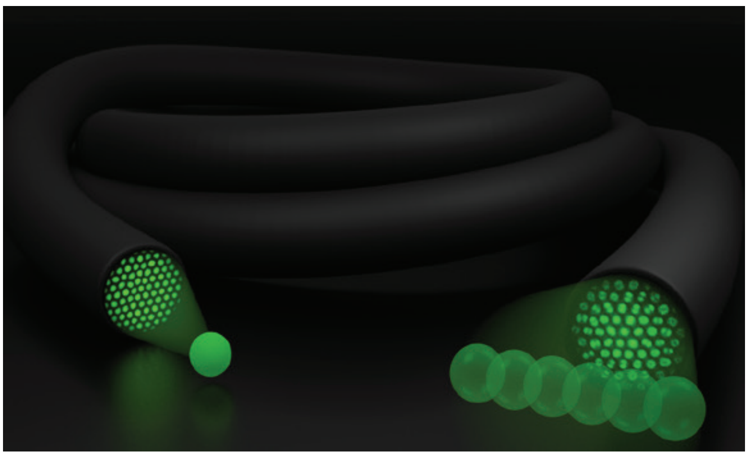
How it works

The research revealed that optical fibre bundles transmit 3D information in the form of a light field. The challenge for the researchers was then to harness the recorded information, unscramble it and produce an image that makes sense. Their new technique not only overcomes those challenges, it works even when the optical fibre bends and flexes - essential for clinical use in the human body. The approach draws on principles of light field imaging, where traditionally, multiple cameras look at the same scene from slightly different perspectives.

Light field imaging systems measure the angle of the rays hitting each camera, recording information about the angular distribution of light to create a "multi-viewpoint image." But how do you record this angular information through an optical fibre? "The key observation we made is that the angular distribution of light is subtly hidden in the details of how these optical fibre bundles transmit light," Orth said. "The fibres essentially 'remember' how light was initially sent in - the pattern of light at the other side depends on the angle at which light entered the fibre."

With this in mind, RMIT researchers and colleagues developed a mathematical framework to relate the output patterns to the light ray angle. "By measuring the angle of the rays coming into the system, we can figure out the 3D structure of a microscopic fluorescent sample using just the information in a single image," Professor Brant Gibson, Chief Investigator and Deputy Director of the CNBP, said. "So that optical fibre bundle acts like a miniaturised version of a light field camera. The exciting thing is that our approach is fully compatible with the optical fibre bundles that are already in clinical use, so it's possible that 3D optical biopsies could be a reality sooner rather than later."

In addition to medical applications, the ultra-slim light field imaging device could potentially be used for in vivo 3D fluorescence microscopy in biological research. The study, in collaboration with CNBP colleagues at Macquarie University and the Centre for Micro-Photonics at Swinburne University, is published in Science Advances.



Modal structure in optical fibre bundles captures light field information. Image credit: Marco Capelli, RMIT.

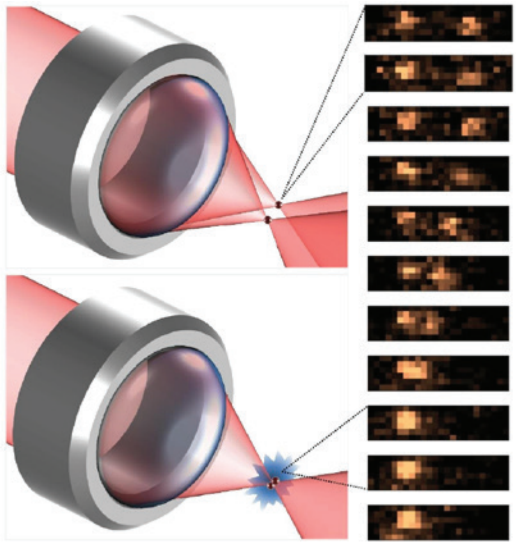
Source material: https://www.rmit.edu.au/news/all-news/2019/apr/3d-optical-biopsies

Original article: A Orth, M Ploschner, ER Wilson, IS Maksymov and BC Gibson, *Optical fiber bundles: ultra-slim light field imaging probes*. Science Advances, **5**, eaav1555, 2019.
DOI: 10.1126/sciadv.aav1555

Atom interaction discovery valuable for future quantum technologies

By breaking with conventionality, University of Otago physicists have opened up new research and technology opportunities involving the basic building block of the world - atoms. In a study published in Nature Communications, researchers put one atom inside each of two laser beams before moving them together until they started to interact with each other. Co-author Associate Professor Mikkel F. Andersen, of the Department of Physics, says this allows the atoms to exchange properties in a way which could be "very useful" for future quantum technologies. "Our work represents an important step in our capability to control the atomic world," he says.

As atoms are like magnets, when the pair start interacting, they start changing each other's direction, counterbalancing each other. It is the first time this "pure test of the basic interaction" has been shown in a lab using two single atoms. Previous experiments have been based on multiple atoms, which can result in undesirable outcomes, such as chemical reactions between the atoms. By showing how to build multi-atom quantum systems from the bottom up, scientists can do things that are not possible using conventional methods.



As the two lasers move together, the atoms interact with each other and exchange properties. Image credit: University of Otago.

"Assembling small physical systems atom by atom, in a controlled way, opens up a wealth of research directions and opportunities that are not otherwise possible. It also leads to the atoms displaying different behaviours than if they were one of many in the system," Dr Andersen says. This includes a finite-temperature quantum entanglement resource. This is significant because entangled particles remain connected, even over great distances, and actions performed on one affect the other. Entanglement can be used to enhance technologies as, because the atoms are interconnected, they can co-operate on a set task, rather than operating on its own. "When we get to the point where we can exploit quantum entanglement, we will have a second quantum technology revolution - like we did with lasers, which made the internet possible. This is why making robust entanglement technology is important - and New Zealand is right at the forefront of this research."

Source material: https://www.otago.ac.nz/sciences/news/news/otago710232.html

Original article: Pimonpan Sompet, Stuart S Szigeti, Eyal Schwartz, Ashton S Bradley and Mikkel F Andersen. T*hermally robust spin correlations between two 85Rb atoms in an optical microtrap.* Nature Communications, **10** (1), 1889, 2019.
DOI: 10.1038/s41467-019-09420-6.

Product News

Large area CMOS beam profiler

DataRay, a global pioneer in the design and manufacture of laser beam profilers has launched the TaperCamD-LCM large area CMOS beam profiler.

The TaperCamD-LCM large area CMOS beam profiler includes industry leading features such as 25 x 25 mm active area, 12.5 µm (effective) pixels and port powered USB 3.0. With a 25,000:1 electronic auto-shutter (79 µs to 2 s) the TaperCamD is suitable for both CW and pulsed laser profiling.

Key features include:

- 355 to 1,150 nm wavelength range.
- 4.2 MPixel, 2,048 x 2,048 pixels, 12.5 um pixels (effective).
- 25 x 25 mm active area.
- HyperCal™ – dynamic noise and baseline correction.
- Isolated pulse triggering and parallel capture.

L-408 compact linear stage

Physik Instrumente, a global leader in the design and manufacture of high precision motion control systems has launched the L-408 compact linear stage.

The L-408 linear stage family with crossed roller guides and anti-creep system offer exceptional stiffness and smooth running ideally suited for industrial and scientific applications. The inherent stiffness of the crossed roller guides allows for smoother running, higher guiding accuracy and a load capacity of 20kg.

Key features include:

- 25 mm travel range.
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- Minimum step size of 100 nm or 500 nm.
- Crossed roller guide with anti-creep system.
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Combined laser diode and temperature controllers

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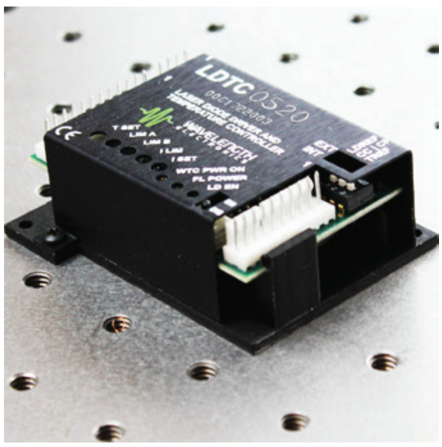
The laser driver is based on our popular FL500, known for low noise output and trouble-free operation. Two models are available, providing either 500 mA (LDTC0520) or 1.0 A output current (LDTC1020). The current limit circuit cleanly clamps laser diode current without ringing or overshoot, and recovers without inducing a phase shift in a modulated laser signal.

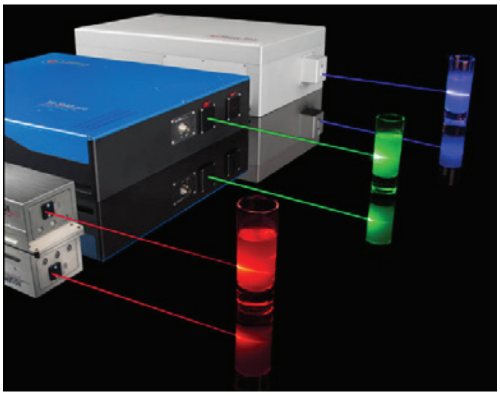
The temperature controller is designed around the WTC3243, our ultra-stable temperature control module known for the ability to sweep load temperature across ambient. Independent cooling- and heating-current limits allow the LDTC to be used with thermoelectric coolers or resistive heaters and either negative or positive temperature coefficient sensors.

Remote computer control is available using the USBKIT, which also allows graphing and datalogging.



For more information, contact Warsash Scientific at sales@warsash.com.au or 02 9319 0122

Toptica UV / RBG Lasers



TOPTICA's frequency-converted diode lasers reach deep-UV wavelengths as short as 190 nm. By providing essential wavelengths like 193 nm, 213 nm, 257 nm or 405 nm in pure cw-TEM00-mode quality, the DLC TA-SHG pro and DLC TA-FHG pro are ideal UV/RGB solutions for testing and inspection or advanced material processing, e.g. lithography patterning. In addition, white-light holography is served with our tunable solutions around 457 nm, 532 nm and 647 nm. The lasers provide more than enough power for each application. On top of that, they are much easier to handle at considerably lower operating costs.

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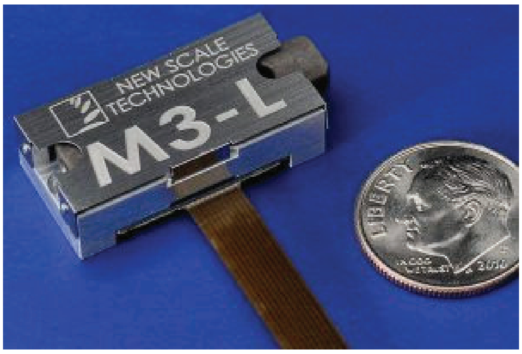
The M3 Smart Modules have built-in controllers. No separate control board is needed. They are ready to plug-and-play directly with your system processor and a 3-6V DC power supply. You achieve the smallest system size, fastest time to market and lowest system cost.

M3 modules are the smallest, easiest-to-use motion systems for adding embedded motion in OEM products. We shrunk the controller and put it inside the module, and use low-voltage piezo motors to eliminate high voltage in the system. No other micro stage is as well-suited for integration into battery-powered, handheld and portable instruments.



Gentec-EO: Wireless laser power measurement for all power levels

Two years ago, Gentec Electro-Optics, Inc. launched BLU, the first wireless laser power meter series. This line of all-in-one detectors combines a detector and a meter with Bluetooth connectivity in one convenient integrated product. This year, we expand the possibilities of wireless by introducing BLU for the XLP series (for low powers down to the microwatts) and for the UP55C high power detectors (up to 2.5 kW).

The small but powerful meter of the BLU series features a Bluetooth connection. You can display the results on your mobile device with the free Gentec-EO BLU app available for both iOS and Android. Need to use it with a PC? Just plug in the included Bluetooth dongle and be ready to make power or energy measurements within seconds.

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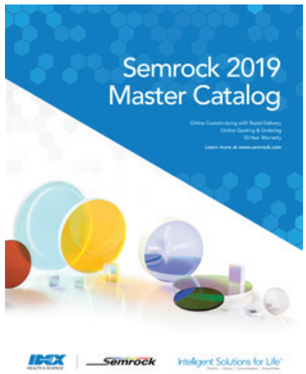

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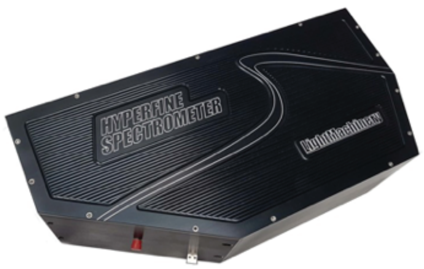

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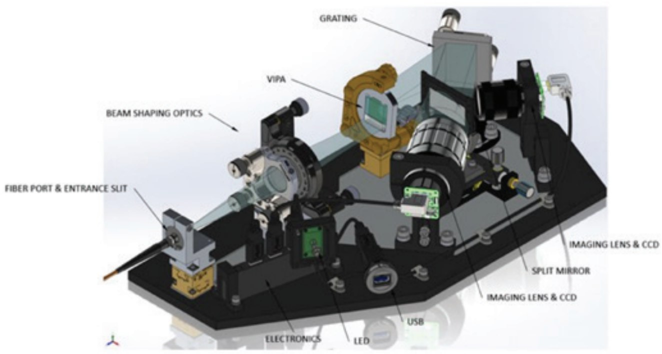

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Sir William Rowan Hamilton

by Tony Klein

Undoubtedly the greatest Irish mathematician who ever lived, Sir William Rowan Hamilton (1805 – 1865) also made important contributions to optics and classical mechanics which would qualify him, in my opinion, as the greatest Irish physicist who ever lived.

While still an undergraduate he was appointed Andrews professor of Astronomy and Royal Astronomer of Ireland and lived at Dunsink Observatory, currently part of the Dublin Institute for Advanced Studies (DIAS). Whilst there, he formulated the most important work shown below:

On a general Method of expressing the Paths of Light, and of the Planets by the Coefficients of a Characteristic Function

By William R. Hamilton, Royal Astronomer of Ireland

Dublin University Review and Quarterly Magazine,

Vol. I, 1833, pp. 795-826.

This reformulation of geometrical optics (i.e. ray optics) and its unification with Newtonian Mechanics, now called Hamiltonian Optics and Hamiltonian Mechanics [1], are central to the modern studies of both areas. Hamiltonian Optics is used in solving problems on light propagation in media with continuously variable refractive index while Hamiltonian Mechanics deals with particle motion in fields with continuously varying potential. (In fact, Hamilton showed that the problems are identical provided that we identify the refractive index on the one hand and the square root of the potential on the other). Examples of application [2] abound, in the study of atmospheric phenomena such as mirages, over-the-horizon propagation problems and, in more recent times, satellite tracking and consequent military applications.

However, the most important applications, from my point of view, are in particle optics, namely electron optics [3], ion optics [4] and neutron optics [5]. In electron optics using only scalar (i.e. purely electric) fields it led to the rational design of vacuum tubes (including space-charge effects) and considerably later, using magnetic fields as well, the development of electron lenses (e.g. originally by Busch [1]) and later in electron microscopes. (It is interesting to note that the incorporation of magnetic potentials anticipated Einsteinian relativity in the equations [6])

Similar considerations apply to ion optics, with applications to ion sources for accelerators, mass spectrometers, ion microprobes, etc. [4].

In the case of neutron optics, entirely different ideas come into play, based on Quantum Mechanics or more precisely wave mechanics, viz. the time-independent Schroedinger Equation, which is mathematically equivalent to the scalar Helmholtz Wave Equation. Here, an equivalent scalar potential, deduced by Fermi and called the Fermi pseudo-potential, effectively averages the interaction with the nuclei in material media. Using this approach, the square-root of the Fermi pseudo-potential leads to a set of phenomena completely equivalent to those in light optics, viz. reflection, refraction, diffraction (Fresnel and Fraunhofer) and Interference (by Wavefront division as well as Amplitude Division) [5]. Furthermore, defining separate effective potentials for the two spin states, polarisation for magnetic fields and for magnetic materials is tractable in very straight-forward ways. Fraunhofer diffraction of neutrons is used in neutron crystallography and is analogous to x-ray crystallography but is, in addition, useful in locating Hydrogen atoms as well as spin states in magnetic materials.

Thus, Hamiltonian Optics and Hamiltonian Mechanics continue to be applicable as valid approximation in the calculations of rays as well as trajectories. Hence my assertion that Sir William Rowan Hamilton is the greatest ever Irish physicist. The 200th anniversary of his birth was celebrated with the issue of a 10-Euro coin, in 2005.

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Active Meta-optics with Halide Perovskites

by Sergey Makarov and Yuri Kivshar

All-dielectric resonant nanophotonics is a rapidly developing research field driven by its exceptional application potential for low-loss metadevices. Active, light-emitting nanoscale structures are of particular interest, as they offer unique opportunities for novel types of light sources and nanolasers. Recently, halide perovskites have attracted enormous attention due to their exceptional optical and electrical properties. As a result, this family of materials has become a prospective platform for modern photonics, overcoming a number of obstacles for classical semiconductor materials. Here we review briefly the recent progress in the field of halide perovskite nanophotonics with the focus on active meta-optics and metasurfaces.

Introduction

Optically resonant nanoscale structures bridge optics and nanoscale science, shrinking light confinement down to the nanoscale via excitation of highly localised optical modes in high-index dielectric photonic structures. This enables the scaling down of a number of important optical devices such as waveguides, lasers, photodetectors, sensors, etc. Historically, metal nanostructures provided the basis for the physics of optical phenomena at the nanoscale and nanophotonic applications related to effective light management in the deeply subwavelength regime [1]. The materials used include gold, silver, and copper, as well as various metal alloys and doped oxides. Dielectric resonant nanostructures have been introduced to overcome optical losses and bring novel functionalities, and they have been studied extensively over the last decade where conventional inorganic materials such as silicon, gallium nitride, gallium arsenide, and zinc oxide were employed due to their high refractive index and well-developed methods of fabrication. However, most of these materials face some limitations related to difficulties with spectral tunability, a lack of excitons at room temperatures, expensive fabrication processes, and low quantum yield. Therefore, more complicated designs with integrated quantum dots or quantum wells have to be applied to avoid these limitations. The next step in the simplification of the developed designs to make them more attractive for large-scale low-cost technological applications is the utilisation of the rising star in material science – *halide perovskites*.

Halide perovskites are materials with a composition ABX_3, where X stands for halide (I^-, Br^- or Cl^-), while A is an organic or inorganic element, and B are cations. They support excitonic states at room temperature, refractive indices (n=2;3) high enough for the efficient excitation of various optical resonances, chemically tunable band gap, high defect tolerance, strong optical nonlinear response, and high quantum yield (in range 30-90%) of photoluminescence [2]. They have already revolutionised solar-cell technologies with performance efficiencies exceeding 22% [3]. The next breakthrough will lead to a novel generation of perovskite-based light-emitting diodes [4] and photodetectors, and the efficiencies of such devices are growing rapidly, promising to overtake many previously developed technologies. In turn, light management at the nanoscale is highly important for such kinds of applications, because light absorption and emission occurs at the subwavelength scale. This raises an important question: can developed nanophotonics make perovskite-based optical devices substantially better? Our recent results suggest that indeed perovskites can be empowered by optical resonances and nanostructuring.

Halide-perovskite meta-atoms

A building block of any metamaterial or metasurface is a resonant subwavelength structure, frequently called 'meta-atom' or 'nanoantenna'. Recently, the existence of strong optical Mie resonances was experimentally proposed for individual nanoparticles with certain sizes made of different types of halide perovskite, as schematically shown in Figure 1a. Indeed, theoretical predictions revealed the optimal conditions for Mie resonance excitation in visible and infrared ranges (see Figures 1b, 1c), which was proven experimentally, as shown in Figure 1d. The Mie resonances were observed both in chemically synthesised nanoparticles and those fabricated by laser ablation, which implies its universal nature and robustness to the method of creation, which is important for further technological applications in optoelectronic devices.

The main advantages of Mie resonances are local field enhancement and far-field control for incident light, and acceleration of radiative recombination at the emission wavelength of the material. The latter phenomenon is called the Purcell effect and results in the enhancement of luminescence efficiency at optical resonances, which is also the case for halide perovskite nanoparticles according to simulations shown in Figure 1e. Indeed, the perovskite nanoparticles made of the most popular composition $CH_3NH_3PbI_3$ in perovskite-based optoelectronics showed strongly improved (up to 5 times) photoluminescence as compared with a thin film [5], as shown in Figure 1f.

Another remarkable feature of resonant halide perovskite nanoparticles is an additional degree of freedom for light-scattering control due to the coupling of Mie resonances with excitons in the material [6]. Generally, when a narrow exciton resonance of any material couples to a broader cavity resonant mode, one can expect interference effects manifested in the characteristic Fano line shape in the spectrum [7]. Such a hybrid Fano resonance is a ubiquitous phenomenon encountered whenever a single resonance of a system interferes with either a nonresonant background or another broader mode. In recent experiments, a pronounced dip in scattering spectra from perovskite nanoparticles caused by exciton coupling with Mie resonances

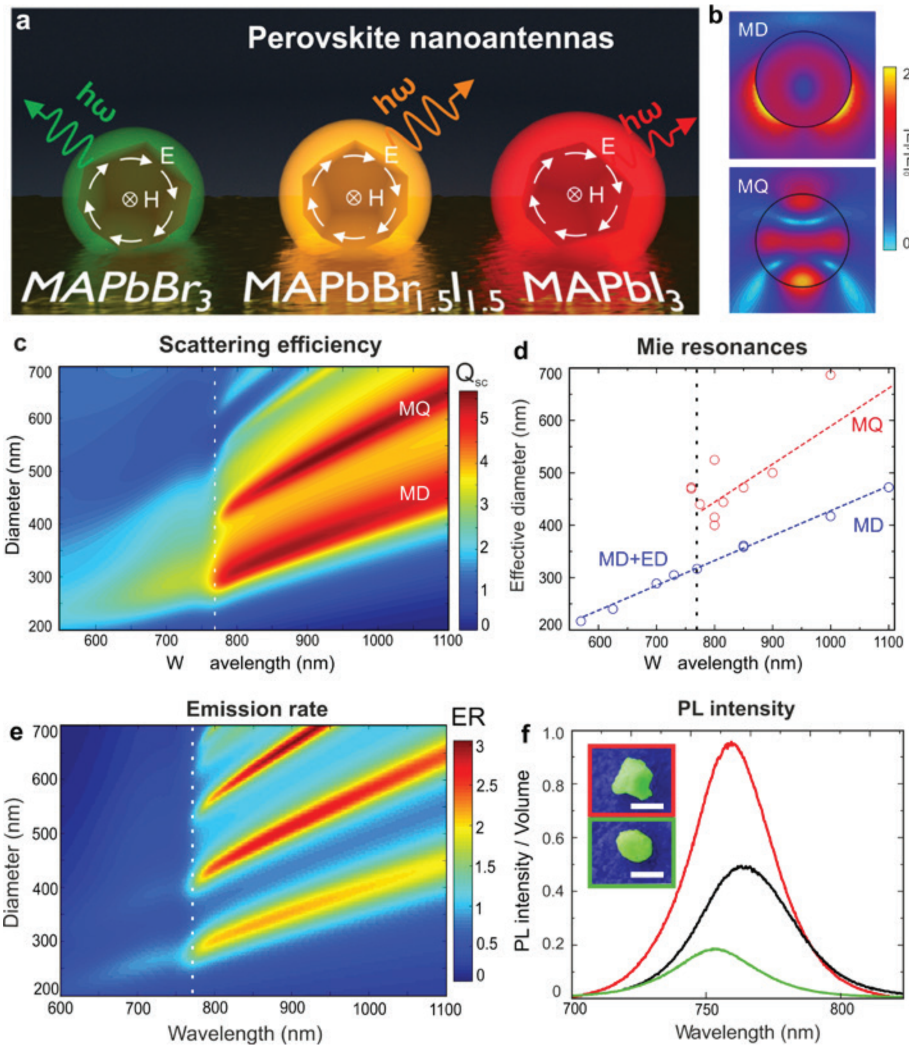

Figure 1. a) Schematically shown concept of halide perovskite nanoantennas made of different compositions. **b)** Numerically calculated near-fields of halide perovskite nanospheres supporting magnetic dipole and magnetic quadrupole Mie resonances. **c)** Analytically calculated dependence of scattering efficiency of a $CH_3NH_3PbI_3$ nanoparticle on wavelength and diameter. **d)** Experimentally measured peak positions of scattering from $CH_3NH_3PbI_3$ nanoparticles. **e)** Analytically calculated dependence of volume-averaged emission rate from a $CH_3NH_3PbI_3$ nanoparticle on wavelength and diameter. **f)** Experimentally measured spectra of linearly pumped photoluminescence from $MAPbI_3$ nanoparticles (red and green lines) and $CH_3NH_3PbI_3$ film (black line). All pictures are adopted from [5].

was observed [6].

Importantly, halide perovskites provide unique opportunities for *in situ* bandgap engineering of optical resonances caused by its strong dependence on the type of halide in the material's composition. This novel approach is based on the anion (I^-, Br^-, and Cl^-) exchange in a gas phase, when the nanoparticles are surrounded by an acid vapour (HI, HBr, or HCl). This approach was applied to resonant nanoparticles as well and resulted in a broadband (~1 eV) tuning of the Fano resonance in a reversible manner by applying different acids in a specific way [6] (see an illustration in Figure 2a). As shown in Figure 2b, the white light transmission spectrum through randomly distributed resonant $CsPbBr_3$ perovskite nanoparticles can be *reversibly* modified upon exposure in vapours of HCl and HBr acids. Moreover, the Fano resonance can be tuned by being precisely fixed at a certain wavelength of the exciton determined by the doping time.

Halide-perovskite metasurfaces

The ordered resonant perovskite nanoparticles or resonant nanostructures (so-called 'meta-atoms') can form a metasurface, as schematically shown in Figure 3a. In Figure 3b and Figure 3c, some realisations of metasurfaces fabricated by means of nanoimprint lithography are presented. The nanoimprint technique proposed by A Zakhidov et al. in 2016 [8] allows for large-scale fabrication of a broad range of two-dimensional nanophotonic designs, and is one of the highest throughput nanofabrication techniques. In order to

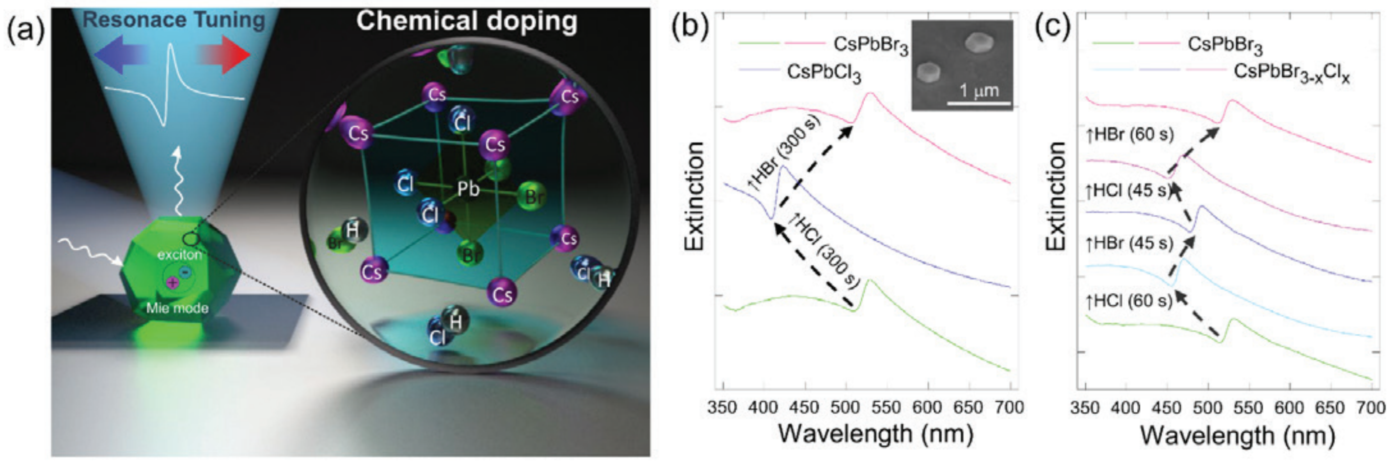

Figure 2. a) Schematic illustration of chemical doping and spectral tuning of the resonances in a perovskite ($CsPbBr_3$) nanoantenna with an exciton upon anion exchange in vapour phase of HCl acid. Experimentally measured extinction spectra of $CsPbBr_3$ nanoparticles chemically tuned in cases of complete **b)** and partial **c)** anion exchange. All pictures are adopted from [6].

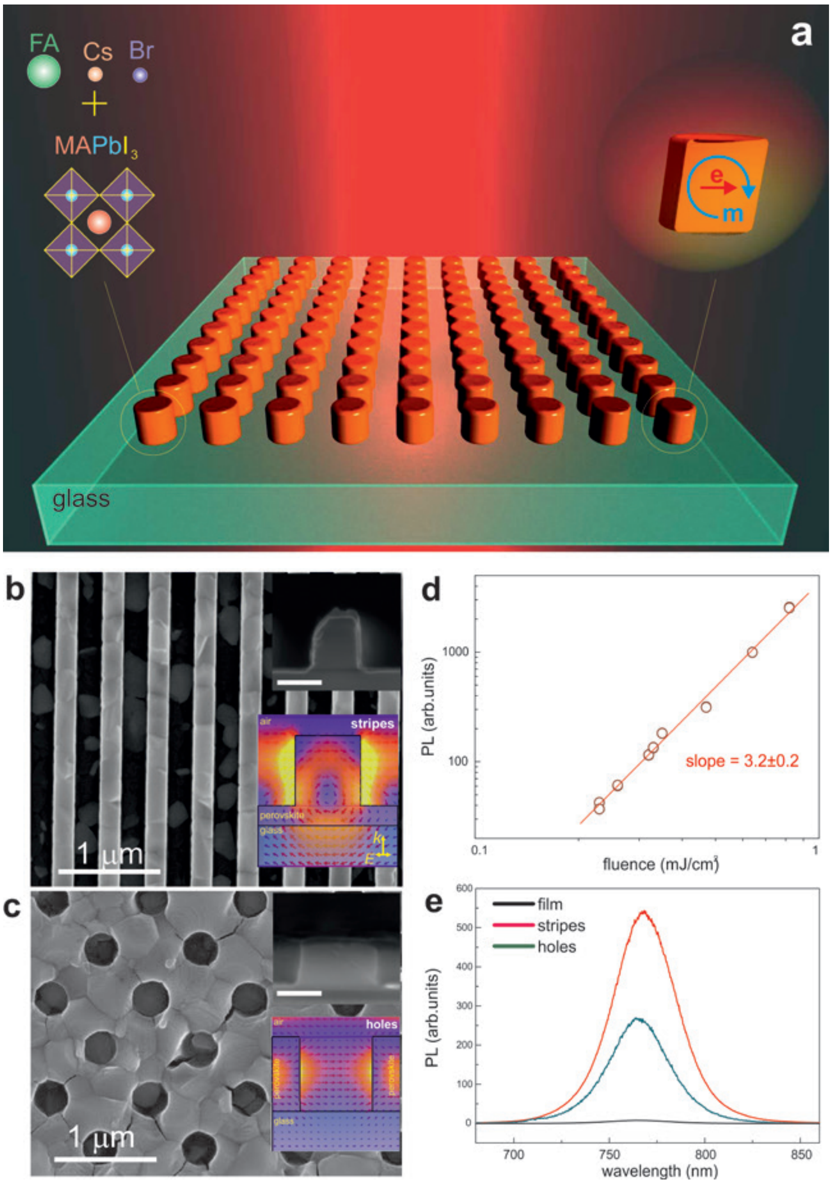

Figure 3. a) Schematic illustration of the concept of halide-perovskite metasurfaces. SEM images of halide perovskite nanosturctures representing stripes **b)** and holes **c)**. **d)** Experimentally measured dependence of nonlinearly excited photoluminescence from nanostructures. **e)** Nonlinearly excited photoluminescence spectra enhanced by various nanostructures (stripes and holes) and film. All pictures are adopted from [9].

create perovskite metasurfaces, focused ion beam and electron-beam lithography were implemented as well. The halide perovskite metasurfaces provide not only nonlinearly excited photoluminescence enhancement [9] (see Figures 3d,e), but also additional structural colouration governed by optical resonances. This paves the way for a display's pixels with tuneable colours originated from resonantly enhanced luminescence and selectively modified reflection properties of halide perovskite metasurfaces.

Concluding remarks

We have presented a brief overview of the most recent advances in the emerging field of active dielectric Mie-resonant nanophotonics based on halide perovskites. This is a rapidly developing research direction with a great potential for applications in new types of light sources, next-generation displays, quantum signal processing, and lasing. A confinement of local electromagnetic fields in resonant dielectric photonic nanostructures due to Mie and Fano resonances can boost many optical effects, thus offering novel opportunities for the subwavelength control of light in active nanostructures. This latest activity in all-dielectric resonant nanophotonics and meta-optics involves naturally active structures as components of future metadevices, which are defined as devices having unique and useful functionalities that are realised by structuring of functional matter on the subwavelength scale.

Importantly, the term of "meta-optics" has a broader meaning, highlighting the importance of optically-induced magnetic responses for many applications, including optical sensing, parametric amplification, fast spatial modulation of light, nonlinear active media, as well as both integrated classical and quantum circuitry and topological photonics, underpinning a new generation of highly-efficient and ultrafast metadevices.

Recently, we have demonstrated the first single-particle all-dielectric monolithic perovskite nanolaser driven by Mie resonances in visible and near-IR frequency ranges [10]. We have employed halide perovskite $CsPbBr_3$ as both gain medium and resonator material that provides high optical gain and allows simple chemical synthesis of nanocubes with nearly epitaxial quality. Our smallest non-plasmonic Mie-resonant single-mode nanolaser with the size of 420nm operates at room temperatures and wavelength 535nm. These novel lasing nanoantennas can pave the way to multifunctional photonic designs for active control of light at the nanoscale.

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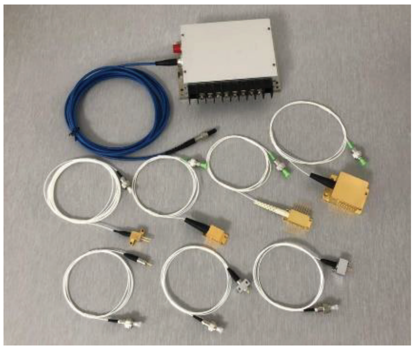

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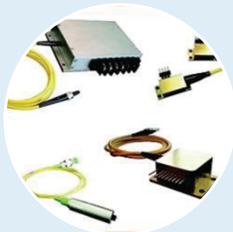

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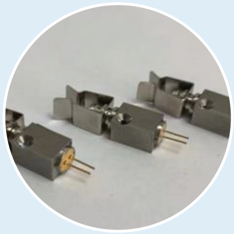

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Optics in Everyday Life: How to Take Better Photos With Your Smartphone, Thanks to Computational Photography

by Rob Layton

This article was originally published on THE CONVERSATION

Each time you snap a photo with your smartphone – depending on the make and model – it may perform more than a trillion operations for just that single image.

Stars are discernible in this image which proves astrophotography is possible on a smartphone.

Yes, you expect it to do the usual auto-focus/auto-exposure functions that are the hallmark of point-and-shoot photography. But your phone may also capture and stack multiple frames (sometimes before you even press the button), capture the brightest and darkest parts of the scene, average and merge exposures, and render your composition into a three-dimensional map to artificially blur the background.

The term for this is computational photography, which basically means that image capture is via a series of digital processes rather than purely optical ones. Image adjustment and manipulation take place in real time, and in the camera, rather than in post-production using any editing software.

Computational photography streamlines image production so everything – capture, editing and delivery – can be done in the phone, with much of the heavy lifting done as the picture is taken.

A smartphone or a camera?

What this means for the everyday user is that your smartphone now rivals, and in many cases surpasses, expensive DSLR cameras. The ability to create professional-looking photos is in the palm of your hand.

I started in photography more than 30 years ago with film, darkrooms, a bagful of cameras and lenses, and later the inevitable switch to DSLRs (with digital single-lens reflex, light travels through the lens to a mirror [the reflex] that sends the image to the viewfinder and flips up when the shutter is fired for the image sensor to capture the image).

But my photography now is done exclusively with an iPhone – because it's cheaper and always with me. I have two accessory lenses, two rigs (one for underwater, the other for land), a tripod and a bunch of photography apps.

It's the apps that often are the powerhouse of computational smartphone photography. Think of it like a hotted-up car. Apps are bespoke add-ons that harness and enhance existing engine performance. And, as with car racing, the best add-ons usually end up in mass production.

That certainly seems to be the case with Apple's iPhone Xs. It has supercharged computational photography through its advances in low-light performance, smart HDR (High Dynamic Range) and artificial depth-of-field: this is arguably the best camera phone on the market right now.

Low-light photography shot on iPhone 8 Plus.

A few months ago that title was held by the Huawei P20 Pro. Before the Huawei it was probably Google's Pixel 2 – until the Pixel 3 came out.

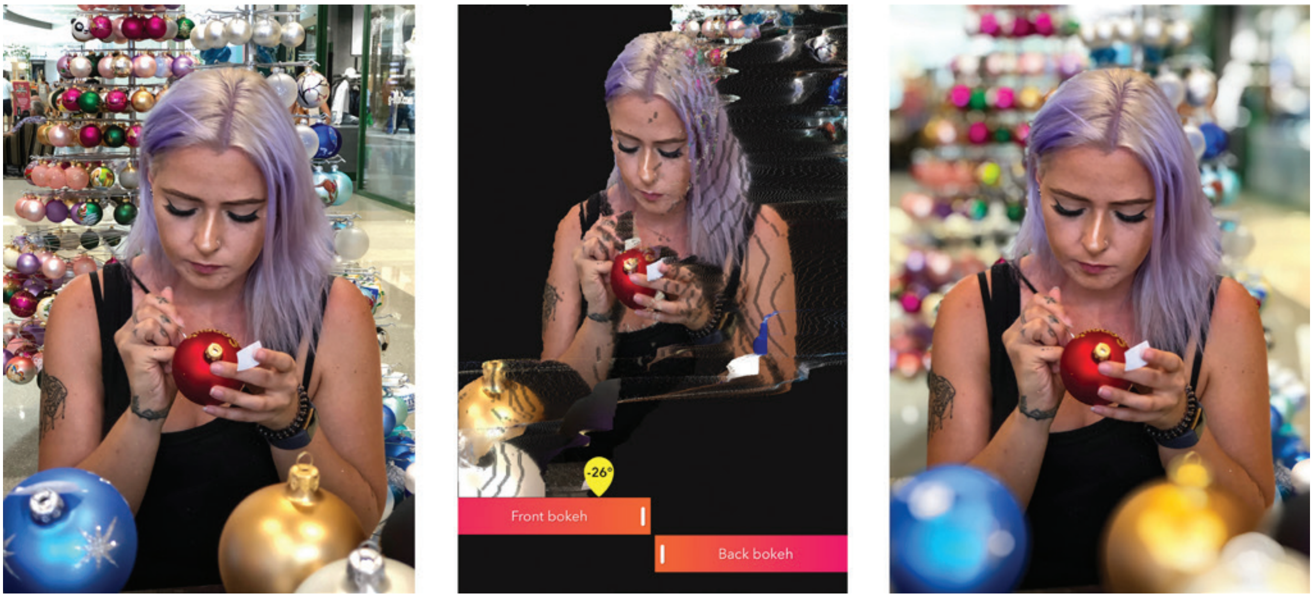
The point is, manufacturers are leapfrogging each other in the race to be the best smartphone camera in an image-obsessed society (when was the last time you saw a smartphone marketed as a phone?).

Phone producers are pulling the rug from beneath traditional camera manufacturers. It's a bit like the dynamic between newspapers and digital media: newspapers have the legacy of quality and trust, but digital media are responding better and faster to market demands. So too are smartphone manufacturers.

So, right now, the main areas of smartphone computational photography that you may be able to employ for better pictures are: portrait mode; smart HDR; low light and long exposure.

Portrait mode

Conventional cameras use long lenses and large apertures (openings for light) to blur the background to emphasise the subject. Smartphones have small focal lengths and fixed apertures so the solution



An image in portrait mode that shows the 3D depth map generated to control the bokeh (blur).

is computational – if your device has more than one rear camera (some, including the Huawei, have three).

It works by using both cameras to capture two images (one wide angle, the other telephoto) that are merged. Your phone looks at both images and determines a depth map – the distance between objects in the overall image. Objects and entire areas can then be artificially blurred to precise points, depending on where on that depth map they reside.

This is how portrait mode works. A number of third-party camera and editing apps allow fine adjustment so you can determine exactly how much and where to put the bokeh (the blurred part of the image, also known as depth-of-field).

Other than what's already in a smartphone, (iOS) apps for this include Focos, Halide, ProCam6, Darkroom. Android apps are harder to recommend, because it's an uneven playing field at the moment. Many developers choose to stick to Apple because it is a standardised environment. That said, you may try Google Camera or Open Camera.

This portrait of a young longbow archer was shot with the Halide app, the background blurred in Focos app, and final editing done in Lightroom CC for mobile. Notice the bowstring disappears in low-contrast areas on the depth map, showing limitations in a technology not yet perfected.

Smart HDR

The human eye can perceive contrast far greater than cameras. To bring more highlight and shadow detail into your photo (the dynamic range), HDR (High Dynamic Range) is a standard feature on most newer smartphones.

It draws on a traditional photography technique by which multiple frames are exposed from shadows to highlights and then merged. How well this performs depends on the speed of your phone's sensor and ISP (image signal processor).

A number of HDR apps are also available, some of which will take up to 100 frames of a single scene, but you may need to keep your phone steady to avoid blurring. Try (iOS) Hydra, ProHDRx or (Android) Pro HDR Camera.

Low-light and long exposure

Smartphones have small image sensors and pixel depth, so they struggle in low light. The computational trend among

HDR exposes for shadow and highlight details to extend the dynamic range.

A three-second exposure of passing storm clouds at midday, made possible through computation.

A long exposure made with iPhone’s Live photo mode.

developers and manufacturers is to take multiple exposures, stack them on top of each other, and then average the stack to reduce noise (the random pixels that escape the sensors).

It’s a traditional (and manual) technique in Photoshop that’s now automatic in smartphones and is an evolution of HDR. This is how the Google Pixel 3 and Huawei P20 see so well in the dark.

It also means that long exposures can be shot in daylight (prohibitive with a DSLR or film) without risk of the image overexposing.

In an app such as NightCap (Android, try Camera FV-5), long exposures are an averaged process, such as this (image above) three-second exposure of storm clouds travelling past a clock tower.

Light trails, such as the image (bottom left) of London’s Tower Bridge and the image (bottom right) of a fire-twirler are an additive process to capture emerging highlights.

A tripod is essential unless you use Adobe’s free editing app Lightroom (iOS and Android), which has a very good camera with a long exposure feature that adds auto-alignment to its image stacking.

Long exposure in iPhone’s native camera app can be made by tapping the Live mode button. The iPhone records before you press the shutter, so you need to keep the camera stable before and after you take the picture. Then, in the Photos app, swipe the image up to reveal four modes: Live, Loop, Bounce and Long Exposure.

The key to successful smartphone photography is to understand not just what your phone can do, but also its limitations, such as true optical focal length (although a new device by Light is challenging that). However, the advances in computational photography are making this a dynamic and compelling space.

It is worth remembering, too, that smartphones are merely a tool, and computational photography the technology that powers the tool. This old adage still rings true: it is the photographer who takes the picture, not the camera. Mind you, the taking is becoming so much easier.

Happy snapping.

Rob Layton is a Senior Teaching Fellow (Journalism) with Bond University.

The original article can be found at: https://theconversation.com/how-to-take-better-photos-with-your-smartphone-thanks-to-computational-photography-107957

All images are courtesy of the author, Rob Layton.

A light-trails long exposure of London’s Tower Bridge, shot on iPhone8Plus using the NightCap app.

Light Trails mode was used to capture this fire twirler at Burleigh Heads on the Gold Coast.

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The meeting will incorporate presentation and discussion of science in plenaries, themed sessions, speed science discussions, and industry engagement forums. The meeting will engage trainees to researcher leaders, chemists to biologists to clinicians to physicists, and academics, industry, and policy makers. With this new multi-conference format we aim to forge new transdisciplinary and translational collaborations.

The event will take place over five days, 8-12 December 2019, in the recently built 'New Academic Street' RMIT University campus on Swanston Street in the Melbourne CBD. On behalf of AOS, SPIE, and the symposium organisers, we invite and encourage you to participate in ANZCOP 2019 in Melbourne, Australia.

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