# Australian Physics

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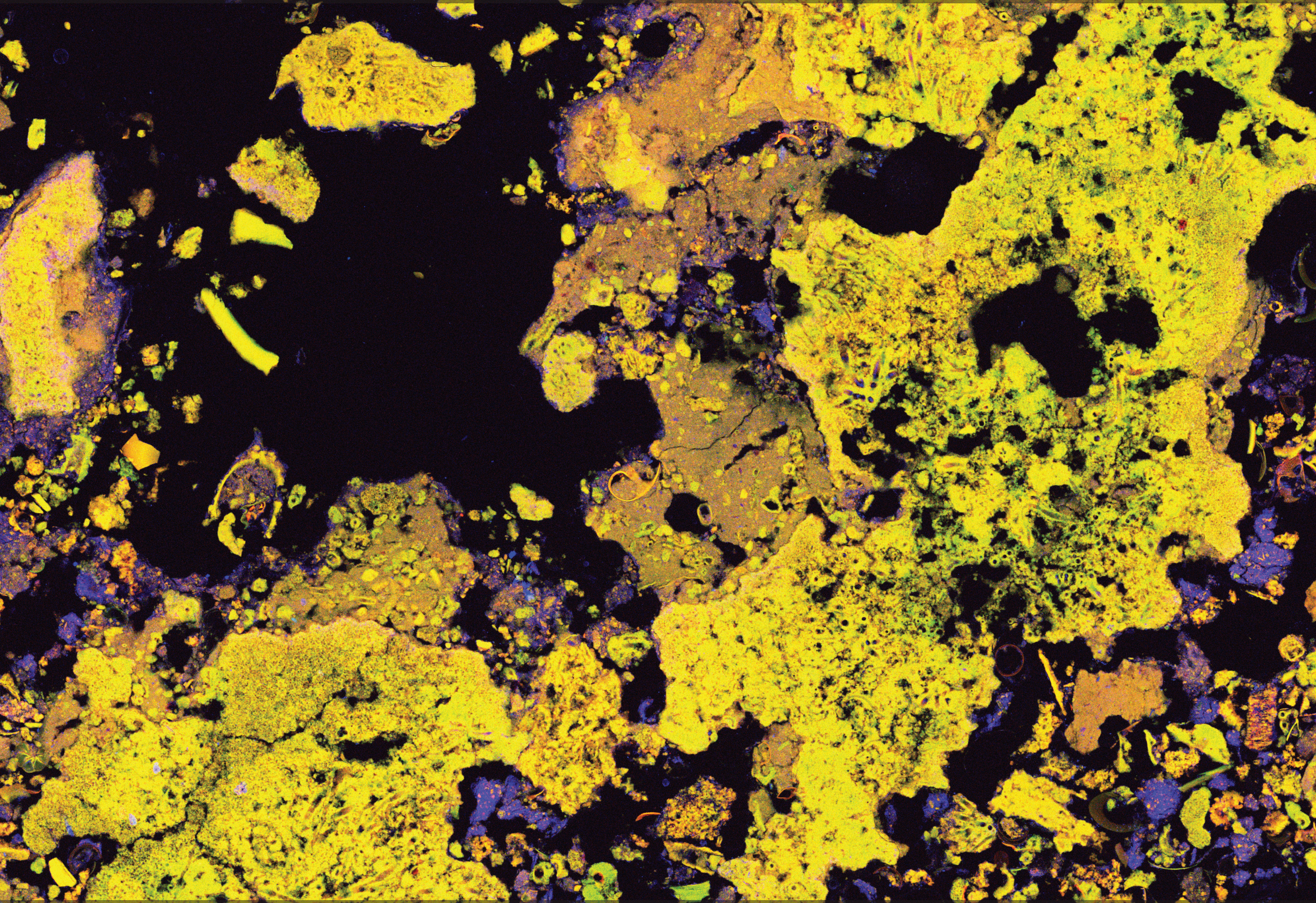

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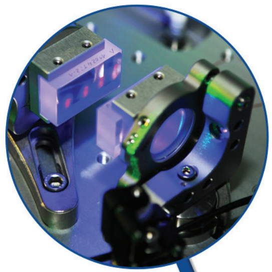

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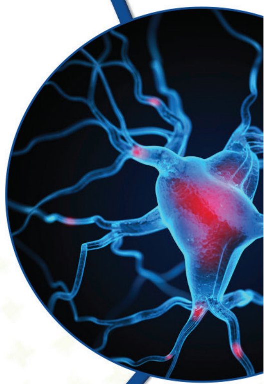

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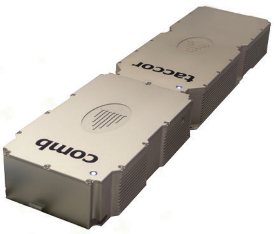


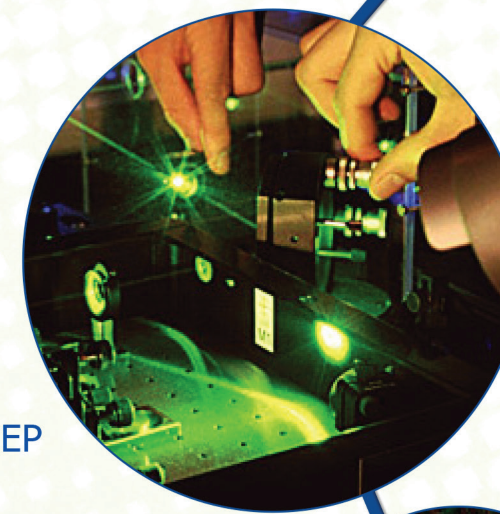

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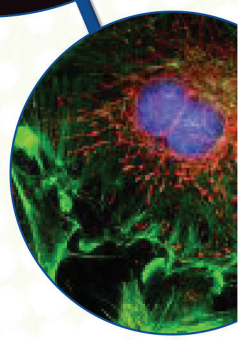

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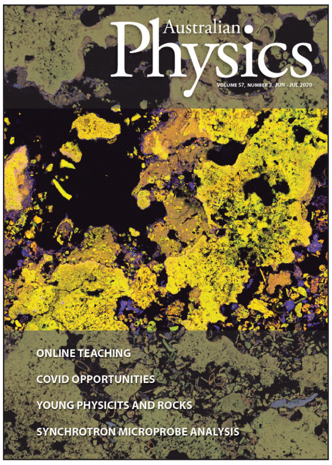


*X-ray fluorescence micrograph of stromatolite from Lake Hawdon, South Australia (Chagas et al., 2016) highlighting seasonal growth patterns. The image is an RGB composition showing strontium in red, calcium in green, and iron in blue - Courtesy Anderson Chagas, Gregory Webb and Gordon Southam (University of Queensland), Robert Burne (The Australian National University) and David Paterson (ANSTO). Data recorded at the XFM Beamline at the Australian Synchrotron, ANSTO.*

*[Chagas, A., G.E. Webb, R.V. Burne and G. Southam. 2016. Modern lacustrine microbialites: Towards a synthesis of aqueous and carbonate geochemistry and mineralogy. Earth Science Reviews 162:338-363.]*

Australian Physics

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# EDITORIAL

## Let's start with a shout-out

There are lots of people who keep the AIP going around the country, and we would like to single out all the volunteers working for the state branches and send them a big shout-out! As various state borders remain closed, your work to connect physicists within your State and, electronically, across States deserves a big Thank You. In this issue we also updated Branch members and email addresses. Let us know if something needs correcting.

A shout-out also to the people who contribute to and support Australian Physics as authors, on the editorial teams, as advertisers, or behind the scenes. Our invitation to join and contribute stands. Feel free to get in touch at aip_editor@aip.org.au .

If we were to pick a theme for this issue, it would be "rocks". Our young physicists will learn more about rocks, and we feature an article about microprobe speciation of silver sulphide in minerals. Our cover shows an X-ray fluorescence map of stromatolite from South Australia and amplifies beautifully how physics connects across sciences. That cutting across also goes for education in physics; even more, education relates closely to research translation. Balancing drilling the basics with research translation is not an easy task, but online delivery offers great assistance (as well as challenges). School teachers are deeply embedded in this, while also mentoring and caring for large groups of young people. So, shout-out to all the physics teachers who survive and thrive in difficult times.

Translating research, connecting physics to the world, and telling positive stories about opportunities is also a feature of the Perspectives section in this issue. Here, we turn our mind forward and ask questions about what opportunities the present pandemic may bring. Ultimately, there is an open invitation out there to all of us to seek and realise opportunities in these difficult times. We are helped by the culture and practice of Physics which builds resilience and a problem solving, growth mindset.

All the best,

Peter Kappen and David Hoxley

# President's Column

## How are Australia's physicists helping in the fight against COVID?

In the last six months the world has experienced a real-life step function in the way we work, study, and live with the emergence of the SARS-CoV-2 virus. It has certainly been challenging. But is has also been heartening to hear about the many ways in which the physics community has helped in the fight against the virus. In this column I am taking this opportunity to highlight a few of the contributions that Australian physics is making in the fight against COVID-19 using our world-class major facilities, skills with data and modelling, expertise in equipment design and manufacturing, research in related areas, and experience in online education. I also ponder how physics can help with the next phase in Australia's economic future.

As early as February 2020, Australia's large science facilities prioritised COVID-related research and were quick to look for ways to help. Facilities such as the Australian Synchrotron (AS) and ANSTO kept their instruments operational to focus on COVID-19-related work. The AS fast tracked access to the Macromolecular Crystallography beamline for COVID-19 related research [1]. This has already been used to determine the 3D-structure of a SARS-CoV-2 protein at atomic resolution which can help in identifying drugs that may be effective against the virus. COVID-19 research has also been supported by physicists at the Australian Centre for Neutron Scattering and I am looking forward to seeing the news from these exciting studies.

Other major facilities such as the Australian National Fabrication Facility with their over 100 experts and 500 tools also rallied and have supported work on sensors and bio-films, including work being done by the innovative start-ups Kimiya and Wearoptimo.

Physicists jumped in to use their modelling and data skills to help understand the possible spread of the virus [2], to create apps that might predict emerging COVID hotspots with symptoms tracking [3], and to create data sharing systems for optimal care [4].

Physicists all around the country also stepped up to immediately fill supply gaps to design, build and manufacture personal protective equipment such as masks and face shields that were used by frontline hospital workers [5].

There has been some lovely work done in the area of lung imaging using X-ray velocimetry by a multi-disciplinary collaboration of physicists, engineers, biomedical engineers and clinicians at Monash University which also holds much promise for understanding the impacts of COVID [6]. Aerosol research by Physicist Prof Lidia Morawska from the Queensland University of Technology, who was elected to the Australian Academy of Science this year [7] is now critical understanding aspects of this disease's spread.

Physicists have also been at the forefront of the education online movement with the ANU's MeriSTEM project [8], proving a popular on-line teaching resource, and the AIP's own Physics Education Group [9] are very active in producing and sharing resources to assist physics departments around the country as they grappled with the constraints placed on them by campus closures. Looking to the future it is not clear how the coming months and years will be shaped by this virus. Indeed, as I write this column Victoria is experiencing a serious spike in cases reminding us that this crisis is far from over. However, in times of rapid change there are always opportunities. We, as physicists, now need to focus on using our expertise and facilities to create and support the innovations that will enable Australia's economy to both recover and thrive. Looking forward it seems likely that there will be an increased emphasis on our domestic manufacturing capabilities and, as experts in making, modelling, solving, building and understanding, I see physics playing a key role in this new stage of Australia's economy.


[1] https://www.ansto.gov.au/news/aiding-global-research-effort-on-covid-19

[2] https://www.abc.net.au/news/2020-03-25/coronavirus-covid-19-modelling-stay-home-chart/12084144

[3] https://beatcovid19now.org/

[4] https://www.youtube.com/watch?v=KIRtCE0kAT4

[5] https://physics.anu.edu.au/news_events/?NewsID=193

[6] https://medicalxpress.com/news/2020-07-world-first-technology-life-cystic-fibrosis.html

[7] https://www.science.org.au/profile/lidia-morawska

[8] http://meristem.anu.edu.au/

[9] https://us14.campaign-archive.com/?u=6d4d211b98df0adf8a3692fe2&id=312c4143cc


Jodie Bradby

# PERSPECTIVES

## Opportunities a pandemic can generate

While society continues to grapple with the range of challenges of COVID-19, there appears to have been a shift. in particular by governments and the general public, in how the value of science, research and innovation is perceived. The crisis has highlighted that effective science engagement and communication is essential to build trust in experts and expertise. On the part of science, this requires being transparent, open, and inclusive. It needs emphasising the value of diverse voices, being comfortable with communicating uncertainty and being clear about the purpose of any communication.

The essential collaborative nature of science premised on international cooperation and transparency provides lessons for governments and policy makers in dealing with global crises. Open data and access to international research infrastructure are good examples of that, and as the OECD notes [1]: "Governments can learn from each other to improve the strategic co-ordination of different policy bodies related to COVID-19 research and innovation".


In light of the pandemic, some challenges for the STEMM community are:

- How can we use COVID-19 to contribute good news stories demonstrating why investment in STI is so important?

- How can the link between science and policy be made stronger and more effective?

- How can the STI ecosystem contribute to re-shaping of future workforces to increase the resilience and agility of communities that were already dealing with anticipated changes due to technology?

**Pivot towards the experts**

The turnaround on trusting people who know something about a topic has recently, for good reason, focussed on professionals and experts working in the health system, including scientists leading research and development efforts to find treatments and vaccinations against the novel coronavirus.

While there is an abstraction layer between what scientists are trying to achieve and what society and policy makers need or require, personal experiences by individuals across all levels of society have the power to generate or amplify trust, especially when tied to personal situations. For example, following his own episode in intensive care after contracting COVID-19, UK Prime Minister Boris Johnson commented that he owed his life to the National Health Service and is quoted "I want to pay my own thanks to the utterly brilliant doctors, leaders in their fields … who took some crucial decisions a few days ago for which I will be grateful for the rest of my life" [2]. These words, even viewed with politics in mind, underscore a personal trauma which has the potential to set the scene for a plausible pivot towards the experts.

For 'the average' person, personal accounts from leaders coupled with their demonstrated trust in and respect of, here, health experts sends a strong signal to follow their lead. Even where they do not have their own tangible experience of surviving the virus, government leaders showing trust in experts should be a positive boost towards regaining broader positive views by the general public of science, research and innovation.

**Good news stories**

For science at large, there is an opportunity to enhance the momentum that is building, but it requires effective engagement and communication to nurture the fragile sprouts of trust we currently seem to observe. A key to this effort is being inclusive, that is, inviting society in and welcoming debate and the contest of ideas.

It is perhaps stating the obvious, but we do need the help of effective science communicators, recognising that not all scientists are skilled in engaging with audiences outside their field, and neither should they have to be. What is needed is to recognise people's strengths and to open doors and break down any barriers for those scientists who are adept at communicating.

Physics sometimes seems to be battling with questions of relevance and its relative importance in the context of broad and recognised challenges in health, food and water security, etc. Yet, physics is relevant to many of these cross-disciplinary issues, as well as areas such as climate change, energy security and maximising societal benefits from the rapid growth of new technologies through the digital economy. Physicists in fact end up working in many roles and jobs which society recognises as essential and relevant. As such, we need to work with others across the STEMM disciplines to amplify the momentum of trust that is building.

**Future workforce**

Governments and businesses at all levels are also significantly investing in what the post-COVID world will look like and, in particular, what this means for the "Future of Work". As recent analyses show (see the latest APEC Bulletin [3] and Deloittes Insights article [4]), the pre-COVID workplace evolution referred to by many as the Fourth Industrial Revolution, encompassing, for example, the internet of things, AI, automation, and quantum computing, is only going to be more relevant as we contemplate the Future of Work post-COVID. Many of these advances come through physics and engineering.

What does this mean for the Physicist of tomorrow? Adaptability and an open mind will be important attributes, alongside with the willingness to engage in the conversation how our work translates into outcomes for society and economy. The world post COVID will be different, and the Physicist of tomorrow will need to continue building up the trust capital. This will require skills and support through well-designed and adaptable education streams, workplaces with the right performance objectives for the individuals, and positive reinforcement and advocacy through organisations like the AIP.

## An acknowledgement

Drought, bushfires, a global pandemic, the events triggering the Black Lives Matter and Aboriginal Lives Matter movements, travel bans that separate loved ones or disrupt study plans, a rise in racism in our community, lockdowns, job uncertainty, home schooling, financial stress on the university sector and the spectra of an economic recession… it is fair to say that 2020 will make history and for most of us it will likely be remembered as the worst of years. In one way or another (or in many ways), we are all doing it tough right now, and of course, some of us are dealing with more challenges than others.

Writing this column gave rise to some discussion within the Perspectives team; would it be tone-deaf to only acknowledge the opportunities from coronavirus? Do people even want to read yet another piece about the virus about that right now? We noted our privileged positions of relative job security, flexibility to work from home and healthy loved ones – these undoubtedly skew our perspective. Indeed, as this edition of Australian Physics goes to print we acknowledge that, with Covid case numbers rising in Melbourne, for those living in Victoria the levels of anxiety are ratcheting up again. While we hope that things will be swiftly brought under control, the reality of living through that coming period is very challenging. Outbreaks are inevitable and could happen anywhere at any time - a reminder that we are a long way from 'normal' and that we must remain vigilant and also look after each other.

No matter what your flavour of challenge is, here at Perspectives we want you to know that we see you and we want to help – let us know what you would like to read about or what resources you might like to see from Australian Physics. In the meantime though, stay safe, wash your hands, be kind and reach out to your community – including your physics community – if you need support.

## References


[1] OECD Policy Response to COVID-19, "Science, technology and innovation: How co-ordination at home can help the global fight against COVID-19", 03 July 2020; http://www.oecd.org/coronavirus/policy-responses/science-technology-and-innovation-how-co-ordination-at-home-can-help-the-global-fight-against-covid-19-aa547c11/ (accessed 14 July 2020)

[2] ABC News, "Boris Johnson discharged from hospital after stint in intensive care with coronavirus", 12 April 2020; https://www.abc.net.au/news/2020-04-12/boris-johnson-discharged-from-hospital-after-coronavirus/12143716 (accessed 14 July 2020)

[3] APEC Bulletin, "COVID-19 altered the future of work", 07 July 2020; https://www.apec.org/Press/Blogs/2020/0703_Future (accessed 14 July 2020)

[4] Insights, Deloittes Insights, "Returning to work in the future of work", 15 May 2020; https://www2.deloitte.com/us/en/insights/focus/human-capital-trends/2020/covid-19-and-the-future-of-work.html (accessed 14 July 2020)

# New Scan

*It's 3 am and I'm about to start a new scan.*

*All I can hear is a constant cacophony of whirrs,*

*humms and a soft periodic thumping from the experiment next door*

*An experimenter enters the hall...*
*dash of light...door slam...footsteps...darkness*

*Sighing deeply, I peer at my screen as the temperature slowly drops*

*65...64...63*

*I check the liquid helium levels and shuffle on my chair*

*60...59...58*

*I realise my concentration on the temperature has muted the chaos of sounds and*
*I spin in a slight panic to check that the bright lights of the servers are still flickering.*
*They hum in a reassuring sort of way*

*I sigh in relief*

*The temperature continues to drop 50...49...48...*

*47...46...45...*

*We are getting close to the set temperature now...*

*Standing and stretching, I slowly begin to move my tired body out of the instrument*
*cabin and down the ladder towards the increasing whirring sound - the pressure is stable at 2 GPa...*

*I glance up at the temperature gauge – my adrenaline spikes –*
*it's 3K from my starting temperature!*

*I shoot back up the ladder, all aches and pains forgotten*

*I swing my head around the door of the instrument cabin - causing the whirring sound*
*to be suddenly replaced by the humm of the servers*

*My eyes are focused on the screen 32...31...30!*

*A split second of silence, then the experiment kicks into life:*
*swoosh bonk…swoosh bonk…swoosh bonk – and we're off!*

*I sigh a large sigh of relief, seeing my first data points coming in*

*I glance at the clock – it's 3:35 am... I can catch about 4 hours of sleep...*

*Tiredness returns in a flood. I throw on my jacket and pad down the metal walkway,*
*the cacophony of whirrs, humms and thumps slowly fading into the distance*

*...dash of light...door slam...darkness*

– **Nicole Reynolds**

# Speciation of silver in sulphide minerals by synchrotron X-ray microprobe analysis

**Rong Fan**
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*Editors' note – This article first appeared in a newsletter of the Australian X-ray Analytical Association (AXAA) and is reproduced here with permission.*

Synchrotron X-ray microprobe analysis of an Ag-bearing ore was conducted at the Advanced Light Source (ALS) to characterise the speciation of Ag and its correlation with other elements, e.g., Cu, Pb and Zn, within the finely segregated heterogeneous ore matrix. These measurements, using synchrotron microprobe X-ray fluorescence mapping (μ-XFM), X-ray diffraction (μ-XRD) and X-ray absorption spectroscopy (μ-XAS), enable comprehensive characterisation of the Ag-bearing components, which are essential to design and/or modify floatation flowsheets for better recoveries of the Ag and other valuable metals [1].

The synchrotron microprobe measurements of the ore were conducted on beamline 10.3.2 of the ALS, Lawrence Berkeley National Laboratory, USA [2]. Figure 1 shows a typical set-up for synchrotron microprobe experiments. The incident X-ray beam dimension was 5 × 5 μm. Characteristic elemental fluorescence emission intensities were measured with a Canberra seven-element Ge solid-state detector mounted at 90° to the incident beam and were normalised relative to the intensity of the incident beam. The chemical associations of Ag, As, Cu, Fe, K, Pb, S, Sr and Zn in the samples were imaged by scanning the sample stage using multiple beam energies. Figure 2 shows selected synchrotron μ-XFM elemental distribution maps of the sample. Fe is dominant over the region and the Fe rich minerals are mainly silicates, further confirmed by μ-XRD analyses. The Ag rich grains (Spot 1 and Spot 2, red coloured particles in Figure 2c) are embedded in large silicate grains, up to 100 μm, and are significantly smaller in size. There is strong correlation between Ag and S which can be seen as purple coloured regions within the μ-XFM map (Figure 2e). No positive correlation among Ag, As and Pb was observed. Other μ-XFM maps were also obtained and two further Ag-containing grains, Spot 3 (Figure 2f) and Spot 4 (Figure 2g), were selected. In Spot 3, Ag is strongly correlated with iodine (I) rather than S. In contrast, Ag is found to be correlated with S and As in Spot 4.

μ-XRD results of Spot 4 (Figure 3) suggests the presence of quartz and pearceite ($(Cu(Ag,Cu)_6Ag_9As_2S_{11})$), a Ag-bearing sulphide. This is consistent with the μ-XRF results which shows the abundance of Ag and S in the grain. Moreover, it appears that, from similar μ-XANES spectrum, Ag in Spot 4 is more likely to be present in pearceite (Figure 4).

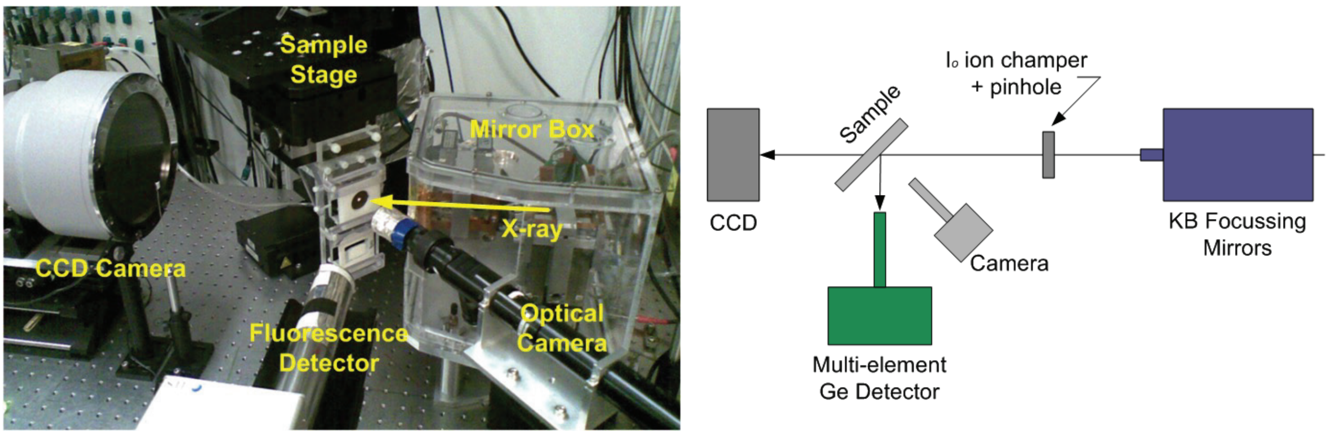


**Figure 1: View (a) and typical layout (b) of synchrotron X-ray microprobe experimental set-up. The view is from end-station ID-13C of the Advanced Photon Source. The diffraction detector (usually a CCD camera) is sitting behind the sample for transmission mode X-ray diffraction measurements. A fluorescence detector (high performance Ge or Si(Li)) is oriented at 90° to the incident micro-beam for μ-XRF and XAS measurements.**

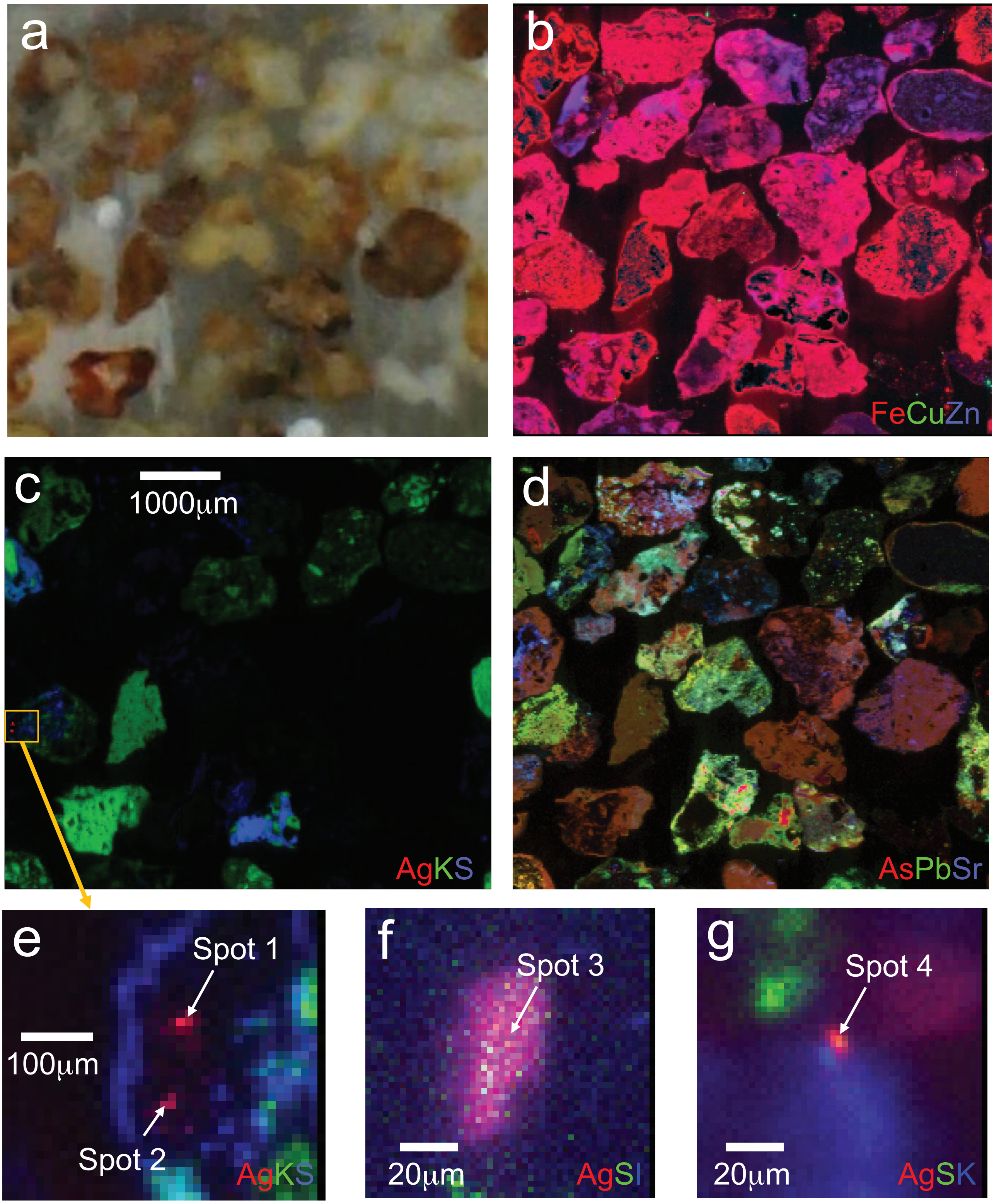


**Figure 2: Optical map of a selected region of the ore sample (a), and synchrotron μ-XFM maps (b-d) for the same region. Two locations (Spot 1 and 2) were chosen for μ-XAS analysis (e). Other μ-XFM maps were also obtained and two further Ag-containing grains, Spot 3 (f) and Spot 4 (g), were selected.**

Figure 4 also shows the μ-XANES (X-ray absorption near edge spectroscopy, a subset of XAS) of the other selected Ag-containing grains as compared to pearceite, proustite ($Ag_3AsS_3$) and acanthite ($Ag_2S$). μ-XANES spectra show clearly significant difference among different Ag-containing sulphide mineral groups. The similarity of μ-XANES data among acanthite, Spot 1 and Spot 2 suggests that Ag in Spot 1 and Spot 2 may be as-

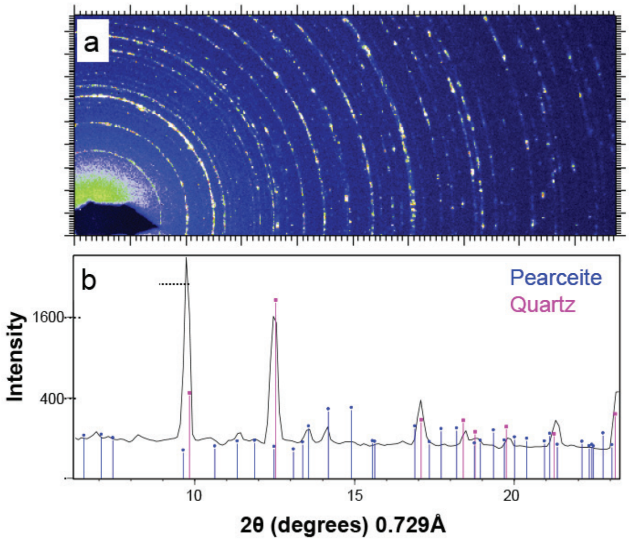


**Figure 3: XRD pattern from the location selected from the µ-XRF map (Figure 2g): (a) 2D µ-XRD image showing both continuous diffraction rings and discrete spot, and (b) XRD trace extracted from the CCD image using the Fit2d software [3]. Background removal and subsequent phase identification were performed with the HighScore Plus software with the PDF-4+ database.**

sociated with a sulphide, possibly acanthite, rather than sulphosalts. Ag in spot 3 is probably associated with iodargyrite (AgI, silver iodide) given that both Ag and I but no S is present. This is consistent with its XANES spectra which shows different features compared to other Ag grains and sulphide standards and an adsorption edge at greater energy by approximately 1 eV.

Mineralogical investigations of the Ag in ores may provide important information towards the understanding of the behaviour of Ag and other metals during industry floatation processes. For example, it is noted that lime has little effect on floatation of acanthite but deleterious on floatation of pearceite, proustite and pyrargyrite $Ag_3SbS_3$ [4]. Starch has a positive effect in improving concentrate grade of the Ag in the floatation of acanthite but should not be used in the floatation of proustite. Lime and starch may therefore be considered for better recoveries of the Ag in the ore type of the sample.

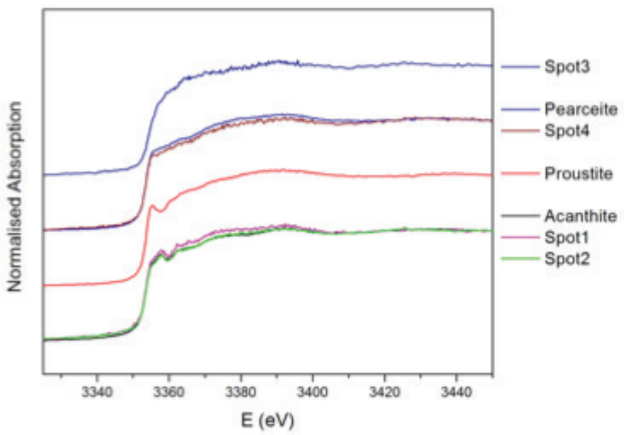


**Figure 4: Comparison of normalised XANES at the Ag $L^3$-edge of selected locations from the µ-XFM maps of the ore and the spectra of Ag references: pearceite, proustite and acanthite.**

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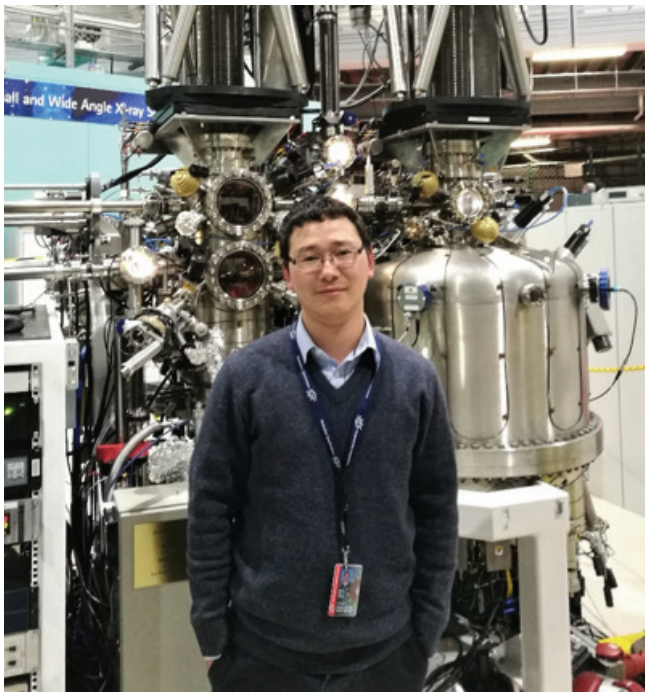

## About the author

Dr Rong Fan is currently a Diffraction Scientist at CSIRO Mineral Resources where he delivers mineralogical and geochemical characterisation services as well as develops diffraction-based capabilities to characterise clay and other poorly crystalline minerals. Prior to joining CSIRO, he had more than 11 years of experience in the application of innovative characterisation strategies to problems with mineralogy, geochemistry and mineral surfaces in complex mineral processing and acid and metalliferous drainage systems at the University of South Australia. His research activities involve extensive use of X-ray diffraction and X-ray absorption spectroscopy, both bulk and microprobe, at Australian and overseas synchrotron facilities.

# Online teaching – Why and how to do it

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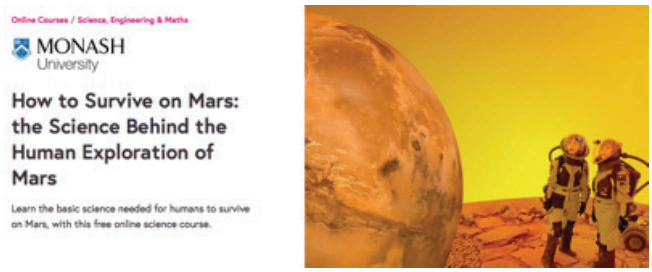
***The COVID-19 pandemic has forced many people to adapt quickly to teaching online. However, there has been increasing interest in online teaching over the past decade. This article summarises a workshop held by the AIP PEG group at the Australian Conference on Science and Mathematics education in October 2019. Online delivery offers several advantages to students: it's flexible so students can fit it around busy lives and can learn from anywhere; students can move at their own pace through material, spending longer on difficult topics and less time on topics they have a good understanding of. Some of the problems with online teaching are how to keep students engaged due to lack of physical interaction or scheduled activities (in case of asynchronous learning). One way to combat this is to contextualise material to ensure that students see its relevance to their lives and/or careers. The workshop covered an online Massive Open Online Course (MOOC) delivered by Jasmina at Monash, an online degree to teach physics to science teachers delivered by Liz at UNSW and a useful set of guidelines for creating effective, engaging videos put together by Petr from the SUPER group at the University of Sydney.***

## Learning from MOOCs

Videos and YouTube were meant to revolutionise education, and MOOCs were meant to disrupt it, but none of that has happened yet. There are a few reasons for that, but the main one is that a learning process cannot be reduced to a simple transfer of information. Learning theories tell us that knowledge is socially constructed and hence there has to be an interaction with instructors and peers for learning to succeed [1]. How can we then use videos and MOOCs to make the learning happen?

I wanted to make an online interdisciplinary science subject with my chemistry colleague Tina Overton, and it occurred to me that starting with a MOOC would be an efficient way to do it - MOOCs are shorter and hence it would be faster to make one, but it would also allow for an efficient "trial and error" process, because having a lot of diverse learners that MOOC attracts would allow for a good amount of feedback and faster iterative improvement. Our MOOC was called "How to survive on Mars – Science behind human exploration of Mars" and was primarily aimed at high-school students and their parents, showcasing possible science study paths at Monash. We got our MOOC approved in early 2016 to be delivered via UK-based FutureLearn platform that Monash signed up with, our launch date was August 2016. We have planned for a 6 week course (or half-semester length), but FutureLearn advised that they noticed that even engaged learners tend to drop off after week 4, so we changed the course to be only 4 weeks, with 3-4 hours of weekly content.



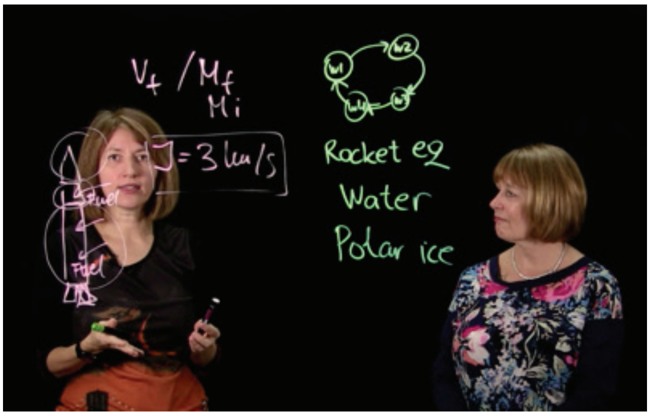

The learning intention of our MOOC was to address the misguided notion that science (and especially physics) is just about equations. Like the book that it was inspired by, The Martian, it meant to show that science is about novel problem solving. While the MOOC was meant to inspire high-school students to take on science subjects, it was also meant to require no prior knowledge so that anyone can take it. We structured the weeks per topics: how to get water, food, energy and air. We sprinkled throughout information and discussions around topics such as getting to Mars, building a habitat, and most importantly ethics of space exploration. Those were the topics that were meant to be covered in additional 2 weeks with the originally-planned 6 weeks of the course, and we knew they were of general interest for the learners and would frame the tasks that learners are given to complete.

Our instructional approach was challenge-based learning: the learners are told they are part of an international Mars mission with 100 crew members trying to live on Mars. As they learn each week about one of the challenges, e.g., how to produce water, they would need to create a mind map of all the factors that influence such production and find a solution. Then as they learn about the next challenge, e.g., how to produce energy in a sustainable way, they would have to modify their mind map and previous solutions accordingly.

Our MOOC followed the basic principles of teaching for STEM [2]. One of the main principles is to avoid cognitive overload - While early MOOCs from edX and Coursera had basically one hour long videos that mimicked the lectures, that model is generally unappealing for the majority of learners. Since then MOOCs have become more sophisticated, paying attention to chunking the information and allowing learners to pause and resume their learning in a more convenient way. The power of MOOC platforms is that they collect a huge amount of data on learners' behaviour, which can help improve the instruction delivery process. Therefore, FutureLearn has guidelines on how long each learning segment should be, what is a good mix of videos, text and other learning resources, which were all very helpful in guiding us. The video segment should be up to 8 minutes long, and the text segment should take up to 20 minutes for the reader to go through, depending on if there is an equation or other extra cognitive work besides just reading the information. The text can be supported by visual aids (graphs and pictures where possible), and videos should follow guidelines for teaching with multimedia [3].

Another important aspect is creating an active learning approach. By asking our learners to create their mind maps we are asking them to construct their own interpretation of core concepts we were trying to teach them. Framing the learning in terms of problems to be solved, prompts the learner to review their own understanding through application. Furthermore, at certain steps the learners are asked to pause and reflect on their understanding through asynchronous group discussions. These discussions were meant to mimic the social side of learning that happens in physical spaces and to encourage learners to examine their understanding by sharing their mind maps and explore different viewpoints by seeing solutions from others. We also had quizzes throughout the weekly lessons to help with understanding and information retrieval practice, as well as a summary quiz at the end of each week. And to stay true to scientific practice, they were asked to perform simple experiments.

Finally, an important ingredient for learning is feedback [4]. The learners were providing peer feedback to each other throughout the week, and they shared a lot of information and relevant personal experience - for example, comparing a diving experience with partial pressure to that of atmospheric conditions on Mars, which really helped other learners see the relevance of science in everyday life. We then recorded weekly videos based on issues and questions discussed in group forums, which our learners appreciated and commented on how that made an important difference in their learning experience in comparison to other MOOCs they've taken which did not provide such feedback.




The course had four runs between Oct 2016 and Nov 2018 and was well received: 23% of the participants joined the course to find out more about Monash; 47% rated the course as excellent, and 37% rated it as good, which equates to a score of 4.24/5. We had 10,000 learners sign up for the first run of the MOOC, of which around 2,500 remained engaged, and FutureLearn told us this was quite a high fraction for their courses. We were also the first course to have equal distribution of learners by age – from 13 year olds to 70+ year olds, everyone wanted to learn about living on Mars! The other runs attracted around 1,500 learners each, of which most remained engaged. We had a significant number of professionals taking the course as they tried to move to the space industry, but most importantly, we had high-school teachers who wanted to adopt the course for their teaching.

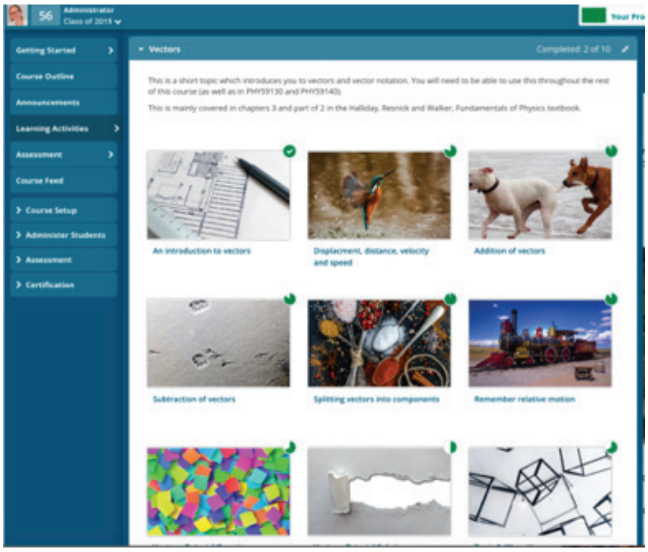
Running the MOOC was a wonderful adventure and has allowed me to hone the skills of online delivery. While I used a blended teaching approach in my courses for the last 5 years, running a fully online course can feel daunting at times, especially in terms of engagement with the 1st year undergraduate students, who are novice learners and need a lot of guidance and support. Running this MOOC convinced me that a careful instruction that follows evidence-based teaching principles can make asynchronous learning and interaction as rewarding as physics interaction with learners. This came very handy this year when we had to switch quickly to online delivery due to COVID disruptions. I basically employed the exact same formula with two of my colleagues in my first year astronomy course, and we have managed to provide an engaging and a successful course.

## Online physics degree for science teachers

Many students, and especially female students, lose interest in physics in junior high school (around year 8). Part of the reason for this is that many high school science teachers lack training in physics, this makes it hard for them to make junior physics lessons interesting and relevant for students and to convey clear conceptual understanding to students. These aspects have been shown to be very important [5] in the development of a "physics identity", especially for female students. Having a positive physics identity increases the likelihood of a student choosing a physics related career such as engineering. Students who do not enjoy physics at junior levels do not choose to study senior physics, the fraction of students choosing senior physics has been steadily decreasing. Compounding the issue, across Australia there is a shortage of physics teachers [6], with 20-40% of senior physics classes being taught by a teacher not accredited to teach physics. To help address this shortfall and hopefully improve the teaching of physics in junior high school, UNSW introduced an online Graduate Certificate in Physics for Science teachers in 2018.

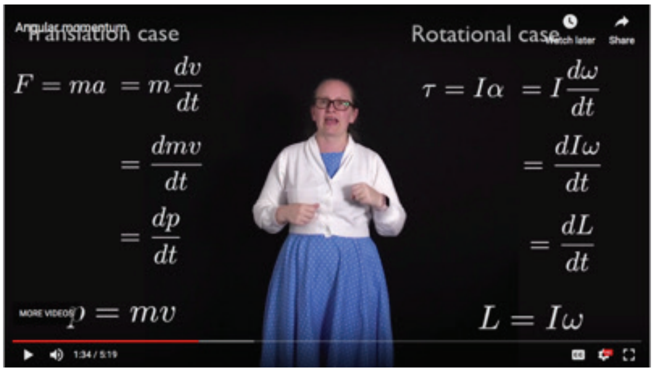
As the degree is online it is accessible to students in rural and remote schools. These teachers make up approximately half the cohort of teachers enrolled in the degree. The department of education sponsors teachers in NSW public schools who undertake the degree, covering a significant proportion of the cost. The degree has been designed with teachers in mind, when demonstrations are shown in videos a description of how they could be replicated in class is given. The courses were developed by people with high school teaching experience. UNSW has a visiting teaching fellow program where high school physics teachers are seconded to the school of physics, UNSW for a year before returning to their high schools. The input from these teachers has been invaluable in the creation of the degree.

The degree is comprised of four courses: Everyday Physics for teachers; Mechanics for teachers; Electromagnetism for teachers; and Thermal and Modern Physics for teachers. The first course is algebra based; it predominantly covers waves looking at how speed cameras, glasses and musical instruments work as well as looking at some thermal physics in the topic on how a hot air balloon works and fluids in a topic on river flow. In this course the teachers are encouraged to think about how they can make physics relevant for their students as well as learning about the physics itself. The later three courses are all calculus based, to be accredited in NSW teachers need to complete at least two courses at higher year level.




It has been well established for decades that making students active learners has a large positive impact on how much they learn from a course (though not necessarily how much they enjoy it! [7]). To keep students engaged the modules in the course consist of short videos followed by questions for the students to answer either about the physics or about how they would teach it. A typical video from the course can be found here: https://youtu.be/Xix5SzRaKOg . Many of the demonstrations are introduced as predict-observe-explain activities where students are first asked to predict what will happen, then watch the video of the demonstration and then explain what happened. Solution videos are provided for all the problems in the course, these are produced using screen-recording from a tablet where problems are solved step by step including detailed explanations of getting from one step to the next.

The assessment of the three later courses consists of 20% quizzes; there are three fairly challenging quizzes with six three part questions pulled from a bank. Students receive a penalty for incorrect answers, along with constructive feedback about how to answer the question. They may take the quiz as many times as they want (receiving a random selection of questions each time) with their highest mark counting towards their final grade.




This encourages them to practice answering questions. The final exam forms 50% of the course mark. The final exam is invigilated either at UNSW or by a senior teacher at their school. The final 30% of the mark comes from laboratory experiments.

In the first year the course ran the laboratory exercises for the three later courses were each held over a weekend at UNSW. There were several advantages to this: it was very useful speaking to the students in person about how the course was going, especially the first year it ran; students all had access to the same equipment and could work in pairs getting immediate help from a staff member if anything went wrong; and, students had access to university equipment which tends to be more sophisticated than the equipment found in many schools. However, it was a large imposition on the rural students who needed to travel and book accommodation for three weekends over the year. In 2019 we decided to move all the lab exercises online. Students were given basic instruction about what to do and then needed to get it to work with equipment available at their school. As well as completing the experiment and collecting adequate data to calculate uncertainties the teachers needed to produce a worksheet to use with their classes. The relevance of this to their teaching was appreciated by the teachers, when asked for feedback about the degree one teacher wrote "The degree was online and assessments resulted in me walking away with practical write ups and tasks I could immediately take into the classroom. These were much more useful in application to the classroom than lesson plans and vague research based analysis of pedagogical strategies."

The experiments for the first course are a little different, as it runs over summer holidays these ones can be completed with household equipment. Students use resonance and a tube in water to measure the speed of sound, use a kettle to measure the specific heat of water and investigate buoyancy and Archimedes principle. In the first course they also design their own experiment to investigate something they find interesting. During the course they peer review each other's experiments, receiving useful feedback before the final submission. They then share their experiments with each other so end up with a number of tasks they can use with their classes.

While only a small number of students have completed the degree so far, four in 2018 then nine in 2019, feedback from students has been very positive. They are using what they learn to improve junior science teaching. "The course itself I would definitely recommend to any aspiring teachers or even any science teachers (Chem or Bio or Head teachers) and I think anyone who completes the course will benefit. The course also has made stage 4 and 5 physics content much more enjoyable seeing applications and being able to see deeper links between concepts" which in the longer term will hopefully lead to more students choosing to study physics in years 11 and 12 and then going on to get a physics or engineering degree.

## Tools that you need for making videos

Creating educational videos does not need to be complex. This section of the article will be a guide to providing a simple way to get started in creating educational video.

Audio - Audio quality is more important that video quality. Luckily, capturing good audio is not particularly difficult, or prohibitively expensive. A decent lavalier microphone would do wonders - you're likely already using them in face to face lectures. I personally swear by the Rode SmartLav+ - just clip it to your clothes, as close to your mouth as possible, plug it into your phone and you're good to go. A slightly more expensive option is to get a wireless Lav mic such as the Rode Wireless Go. If you want to get even fancier, shotgun microphones are great - they're designed to only capture what you're pointing at, and block out all other sounds. When recording audio, put the microphone as close to your audio source (your mouth) as possible - you're trying to maximise signal to noise. To save the hassle of synchronising things later, I recommend plugging your microphone into whatever you're using to record your video.

Video - Chances are, the best camera you have is your phone. An iPhone 5s was used to shoot an entire feature-film that made almost a million dollars at the box office. If the quality is good enough for feature films, it's good enough for educational video. The stock camera app on your phone is great for most situations, but if you need to adjust focus/exposure/frame-rate with a little more fidelity, you can use an app like FilmicPro.

Don't forget to use the slow-motion capabilities - especially useful when you're filming a lecture-demonstration to include in your video. Put your phone or camera at about face height - you don't want the students down or you, or up your nostrils. I recommend shooting 1080p (also known as full-HD) as opposed to 4k. The extra resolution is nice but is not worth the larger file sizes, and the extra trouble while editing.

Software - There are three common software packages you can use to edit. Final Cut Pro/iMovie, Adobe Premiere Pro, or DaVinci Resolve. Fundamentally. They all do the same thing - you import your video and audio files, and cut them together. The main difference is in the user interface. Final Cut Pro (paid) and iMovie (free) run only on Mac, Adobe Premiere Pro requires a subscription service (that your university may already have), and the free version of Resolve is more than powerful enough for most cases. While I am personally a big fan of Final Cut, it's really your choice - try things out and see what works for you. It is worth noting that video editing is CPU and GPU intensive - it might be worth doing on the most powerful computer you have. This is also another reason to shoot 1080p, rather than 4k - it is much quicker to edit and render 1080p files.

## About the authors

Dr Jasmina Lazendic-Galloway is a senior lecturer in the School of Physics and Astronomy and the PEG Chair. Her research interests include how active teaching methods improve student learning, engagement and retention; using assessment to develop self-regulated learners; using videos to role model approaches to problem-solving to novice learners and academic adoption of active teaching approaches.

A/Prof Elizabeth Angstmann is an education focussed academic and first year director in the School of Physics at UNSW. After completing a PhD in theoretical physics Liz worked as a high school teacher for a couple of years before returning to UNSW. She introduced, developed and co-ordinates the graduate certificate in physics for science teachers.

Petr Lebedev is a final year PhD student in the SUPER group and science communicator at the University of Sydney. His research focuses on reflective thinking in educational multimedia. You can reach him at hello@sciencepetr.com.

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# The Young Physicist and Rocks

***Physics often focuses on the very large (Astrophysics) or the very small (Particle Physics), with good reason. However, physics has a lot to say about everything around us- including what's at our feet. This Young Physicists' column considers the rocks and minerals in our everyday environment.***

## Rocks are often crystals..

Rocks are crystals consisting of a combination of all sorts of atoms, including metals, oxygen, silicon and sulphur.

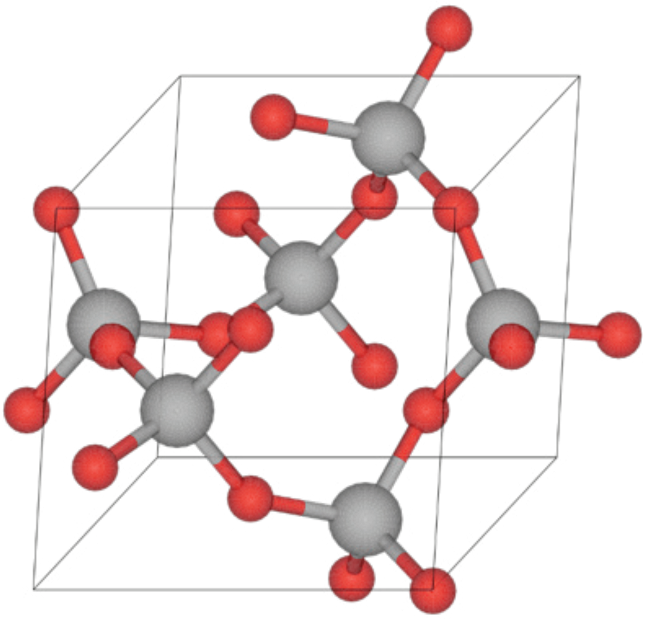


**Figure 1: Crystal structure of quartz. Red balls are oxygen, grey balls are silicon) [1].**

**Figure 2: a cluster of pure quartz crystals from Tibet [2].**

One of the most common rocks you will see in Australia is quartz. It is made up of silicon and oxygen atoms bound together in a regular repeating pattern, two oxygens for every silicon. You can picture it as a very plain Minecraft world, where all the bricks are the same, and look a bit like the image in Figure 1.

The regular, ordered structure of crystals lends strength to the resulting mineral. It also often happens that the electrons in the crystal are tightly bound so that they don't interact with light- and the crystal is transparent, like the quartz crystal in Figure 2.

## ..but they don't have to be

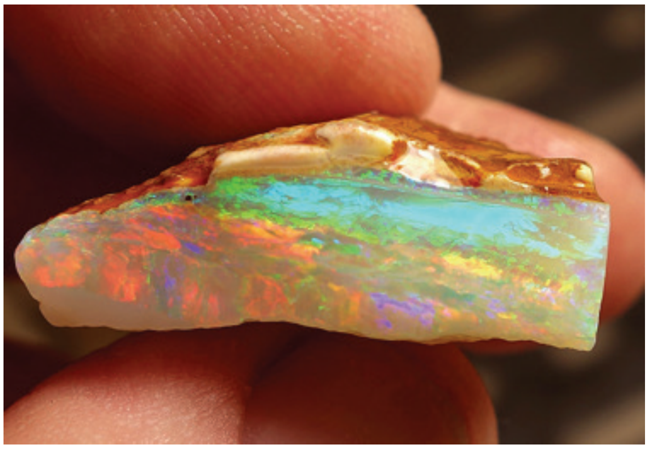


**Figure 3: Opal from Coober Pedy [3].**

Sometimes when SiO2 is formed in the earth, it doesn't have the regular crystalline structure shown in Figure 1, and it becomes less transparent and less strong. Solids which are not crystalline are called amorphous; Figure 3 shows Opal, an amorphous version of SiO2 which has some water trapped in it, forming tiny structures which cause light waves to react with each other to enhance some colours and cancel others. This causes a dramatic 'fire', where different colours 'pop' out of the rock.

## Stone Age Electronics

In a sense, computers are made of rocks. Modern electronics are based around crystals of silicon, with some SiO2 regions arranged in a very cunning way. The Silicon has small amounts of impurities introduced so that it conducts electricity in a very controllable way, allow-


**Figure 4: Crystals of Galena (l ead sulphide) used for receiving radio transmission in Poland in 1939 [4].**

ing the conductivity to be turned on and off to form the zeros and ones of binary logic.

Some rocks have been used straight from the ground to make electronics. Figure 4 shows crystals of lead sulphide (Galena) which can be used to detect radio waves. They were also part of the development of Radar, which was so important in the second world war. Galena is an example of a naturally electrically conducting mineral- the natural equivalent of the Silicon crystals in our computers and phones.

## Minerals of the space age

Quartz and Galena are made of only a few different sorts of atoms- but many minerals are complex combinations, which can make their crystals have very interesting properties. Mica crystals are packed with metals, silicon, oxygen and fluorine, so that it forms layers of very thin sheets- a close-up is shown in Figure 5. This structure means that it conducts heat very well, but not electricity. It's also very strong, and the sheets can be separated to make very thin layers. It's used in electronics and even in radiation detectors, because it lets radioactivity through but keeps the air out.

## Over to you

Next time you go for a walk, look at the stones and rocks around you. Take a photo of any that look interesting, and email them to aip_editor@aip.org.au, and we'll tell you their story.

## References

[1] https://en.wikipedia.org/wiki/File:%CE%91-Quartz.svg

[2] https://en.wikipedia.org/wiki/File:Quartz,_Tibet.jpg

[3] https://en.wikipedia.org/wiki/File:Coober_Pedy_Opal_2.jpg

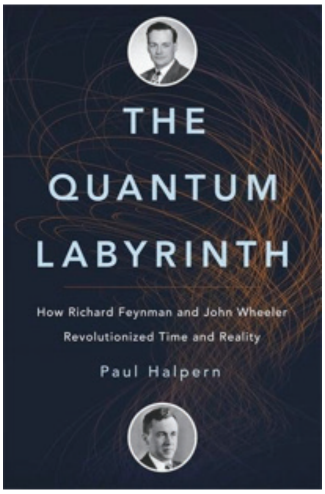
[4] https://en.wikipedia.org/wiki/Crystal_detector#/media/File:Galena_crystals_for_use_in_crystal_radios.jpg

[5] https://en.wikipedia.org/wiki/File:Mica_(6911818878).jpg

**Figure 5: Structure of mica, showing the thin sheets of crystals which give this complex mineral its space-age properties [5].**

# BOOK REVIEW

## The Quantum Labyrinth: How Richard Feynman and John Wheeler Revolutionized Time and Reality




**By Paul Halpern, Basic Books (2017), 336 pages; Print ISBN: 978-0465097586.**

**Reviewed by Michael Hall, Honorary Senior Lecturer, Department of Theoretical Physics, Australian National University, michael.hall1@anu.edu.au**

Much has been written about the extraordinary Richard Feynman, including by himself, but rather less about his remarkable mentor, John Wheeler – an intensely sober and conservative man on the outside but internally seething with wildly speculative ideas. While many of these have not passed the test of time, others have developed into important parts of theoretical physics. As Feynman himself acknowledged: "This guy sounds crazy… But when I was his student I discovered that if you take one of his crazy ideas and you unwrap the layers of craziness from it one after another, like lifting the layers off an onion, at the heart of the idea you will often find a powerful kernel of truth."

A nice example is when Wheeler excitedly rang Feynman to tell him of a new crazy idea: that there is only one electron in the universe, furiously zigzagging back and forth in time and appearing to be a positron during the backward zigzags. This notion ultimately failed (we see more electrons than positrons), but the concept of positrons as electrons travelling backwards in time has become crucial in quantum field theory. Wheeler also proposed a precursor to quark theory (with all particles formed from electrons and positrons); how field lines threading wormholes in spacetime could generate "charge without charge"; and a delayed-choice experiment that further sharpened the conundrums of quantum mechanics.

As well as emphasising the importance of new ideas in sparking valuable directions of thought – even when the original forms fall by the wayside – there are many refreshing instances where Halpern does not merely recount the personal lives and collaboration of the two main protagonists, but shows how their scientific inspirations and insights were embedded in a cloud of interactions with others – somewhat analogous to the propagation of electrons through a virtual cloud of vacuum excitations.

For example, Feynman's first collaboration with Wheeler showed how the classical electromagnetic field, which carries interactions between charged particles, can be replaced by a direct action at a distance between the particles, that acts both forwards and backwards in time. This crazy idea, "Wheeler-Feynman absorber theory," has not survived. However, in trying to find a quantum version, Feynman was led to search for an action-principle formulation of quantum mechanics. He soon became stuck, and it was only the good fortune of meeting an exiled German physicist at a party, Herbert Jehle, that provided the way forward.

In their serendipitous conversation, Jehle pointed Feynman to an obscure paper by Paul Dirac, quickly leading to Feynman's first major lasting result: the representation of quantum evolution via the sampling of all possible paths between an initial and final configuration. Whereas a classical particle takes only one path between two points, a quantum particle evolves as if it explores every possibility. Dubbed "sum over histories" by Wheeler, it formed the kernel of Feynman's PhD thesis, and eventually of the famous Feynman diagrams that lie at the heart of his Nobel prize winning formulation of quantum electrodynamics.

Halpern pays particular attention to the history and players involved in bringing quantum electrodynamics into being, as well as to those whose breakthroughs were influenced by Feynman and Wheeler – including Hugh Everett (inventor of the "many worlds" interpretation), and Kip Thorne (part of the Nobel prize winning collaboration that directly detected gravitational waves). The complementary contributions by Feynman and Wheeler to the development of the atomic bomb are also described. Ideas are illustrated for the general reader with thoughtful and sometimes amusing analogies.

This is an excellent piece of popular science writing, bringing the excitement of scientific research to life – including its many missteps and brilliant leaps – through the lens of two giants in twentieth-century physics.

# #PhysicsGotMeHere

***This occasional column highlights people who have a qualification in physics but are in roles we might not traditionally associate with physicists. The information is drawn from the 'Hidden Physicists' section of the AIP e-bulletin.***

**Toby Hendy**
**YouTube Content Creator**
**https://tobyhendy.com/contact/**

I make videos about physics and maths on my YouTube channel 'Tibees'. My work combines my interests in science communication and video production and requires an understanding of how to stand out in the world of digital media.

On any day I could be brainstorming video ideas, researching a topic, filming, editing, making thumbnails or collaborating with other creators. I support the channel through Google Adsense (the ads that you see on YouTube), sponsors and Patreon (a site where people sign up for extra content).

Some of my popular videos include me going through exams from around the world, explaining math concepts outdoors in a relaxed setting, and talking about the history of science.

I did a Bachelor of Science majoring in physics and math at the University of Canterbury, NZ and then Honours in physics at ANU. I started a PhD in physics but left to pursue YouTube full time. I have been making science videos as a hobby since high school and it took me about 5 years to get my first 100 subscribers but now my channel has over 440,000 subscribers and 46 million total views YouTube link: https://www.youtube.com/user/tibees

**Andreas Schreiber**
**Lead, Bioinformatics**
**SA Pathology**
**andreas.schreiber@adelaide.edu.au**

I lead the bioinformatics groups of the Centre of Cancer Biology and the ACRF Cancer Genomics Facility in Adelaide. Working together with teams of biomedical researchers, we use computational and statistical techniques to analyse molecular data produced with the aid of modern high-throughput genome sequencing machines. The outcomes are used, for example, to advance knowledge of fundamental processes leading to the progression of cancers, and to help uncover and understand the role of a multitude of genetic mutations that give rise to various leukemias, developmental and neurological disorders. Because we are embedded in the state health system, we also play an important role in translating our research outcomes directly into developing new diagnostic services provided by SA Pathology.

I obtained a BSc (Hons) and MSc in physics at the University of Melbourne and then moved to the University of Adelaide to study for a PhD in theoretical nuclear and particle physics. After 12 years of postdocs overseas and an ARC research fellowship back in Adelaide, I switched careers and moved into the emerging research areas of bioinformatics and computational biology. I was introduced into this by first working in plant bioinformatics and, for almost a decade now, in the biomedical area.

While at first sight moving from physics to bioinformatics may appear to be a dramatic change (it is certainly true that lately I have not had too many occasions to solve any equations of motion!), in many ways a background in the archetypal quantitative and computational science is ideal preparation for working in a field increasingly being dominated by 'big data'. It is no accident that many of the techniques used in bioinformatics had their origin in the physical sciences and, indeed, it is rare for me to attend a conference where I do not meet fellow physicists. To name a few, Markov processes, subtle signals hidden in high-dimensional matrices of noisy data, Eigen decompositions, data visualisation and mathematical modelling are all part of the lexicon of researchers working in either discipline.

Taking a step back, it is fun to reflect on general similarities and differences between the two parts of my career. Then and now, as a researcher I still spend my days learning new things and solving puzzles. Alas, I also still spend time battling with referees, funding agencies and University bureaucracies, but no need to dwell on that.

Both in physics as well as now I have had the luck and privilege to work with inspiring mentors and colleagues that get as excited as I do by new discoveries or sudden moments of clarity. When working as a physicist, I always got joy out of seeing concepts developed in one area crop up in seemingly unrelated ones, leading to the realisation that they are not unrelated at all. As a bioinformatician, the same is true in spades, given that the field borrows concepts from areas as diverse as physics (of course), computing and information theory, statistics and even computational linguistics.

Publishing a good paper still brings great satisfaction as well. But there are also differences, some unexpected. From time to time – as before by staring at my computer screen, still trying to extract meaning from noisy data -- I am now able to directly contribute to the improvement of cancer treatment of a patient or provide genetic information that helps a young couple with their family planning. This is a routine satisfaction for any medical professional, of course, but I was completely unprepared for the pleasure it brings to be able to use skills acquired as a physicist a long time ago in this unexpected new way.

# SAMPLINGS

## CERN approves further work on Future Circular Collider – but delays final decision

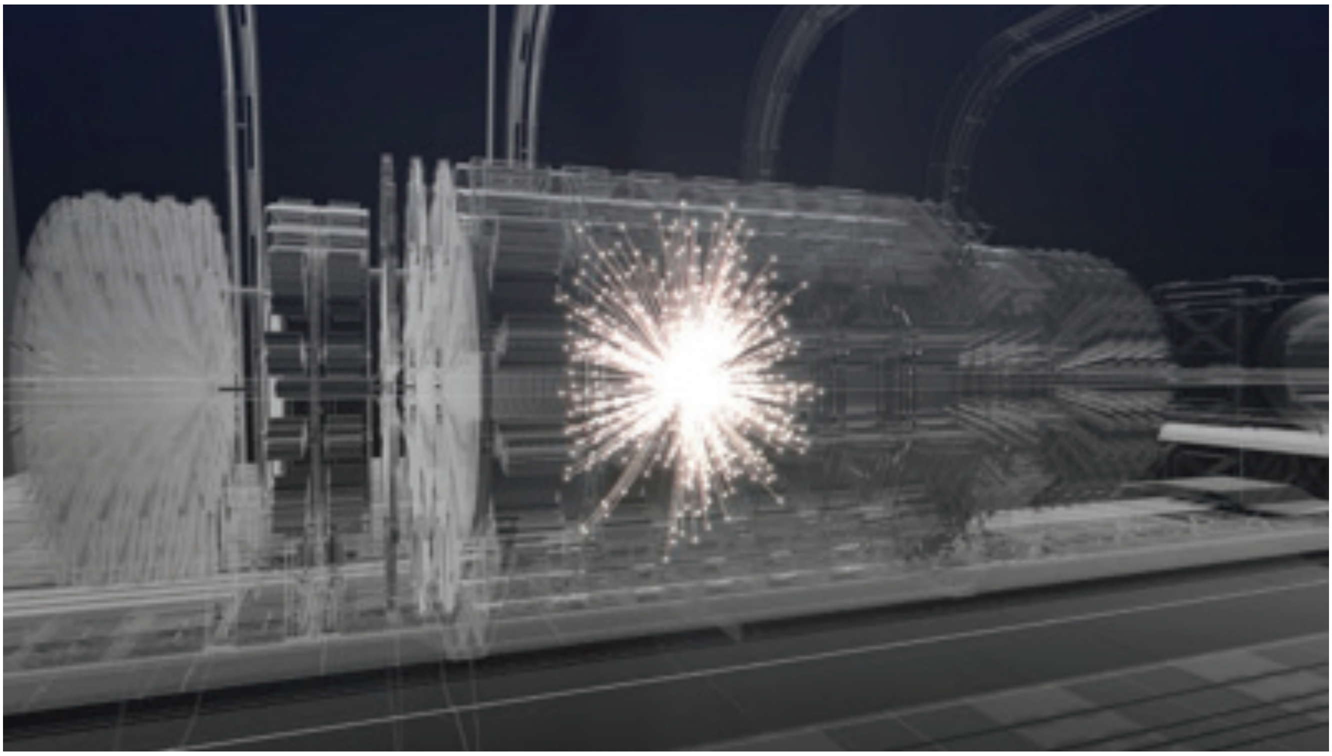
The report sets out a plan for the future of particle physics in Europe to the mid-2020s and beyond. It especially concerns planning the next collider that would succeed the Large Hadron Collider, which first switched on in 2008. The 27 km-circumference LHC has been smashing protons together at energies up to 13 TeV in the hunt for new particles and in 2012 physicists announced they had discovered the Higgs boson with a mass of 125 GeV.

The LHC is currently undergoing a major £1.1bn "high luminosity" upgrade – dubbed HL-LHC – that will increase the collider's luminosity by a factor of 10 over the original machine. The strategy indicates that the completion and exploitation of the HL-LHC should remain "the focal point of European particle physics".

The strategy update, however, gives the green light for further study into the FCC, which would cost around £20bn. In January 2019, CERN released a four-volume conceptual design report for the FCC, which first called for the construction of a 100 km underground tunnel that would house an electron–positron collider (FCC-ee). The FCC-ee would focus on creating a million Higgs particles to allow physicists to study its properties with an accuracy an order of magnitude better that what is possible today with the LHC.

Once the physics programme for the FCC-ee is complete, the same tunnel could then be used to house a proton-proton collider, dubbed FCC-hh. The FCC-hh would use the LHC and its pre-injector accelerators to feed the collider that could reach a top energy of 100 TeV – seven times greater than the LHC. CERN will now carry out a more detailed costing of the FCC as well as continue research and development into the magnet technology that will be required for such a machine at higher energies.

The strategy also approves European participation in the ¥800bn ($7.5bn) International Linear Collider (ILC) if it receives support from the Japanese government. First mooted over a decade ago, the ILC would accelerate and smash together electrons with positrons at 125 GeV in a 20 km tunnel to study the Higgs boson and other particles in precise detail.



**Grand designs: the CERN council have endorsed a plan for the coming decade in particle physics that includes further design work on the Future Circular Collider. (Courtesy: CERN)**

In March 2019, officials in Japan said that their government has formally "expressed an interest" in the particle smasher but did not decide whether to host the machine. The final go-ahead will only be given if enough international support and funding can be found to construct the machine and there is a consensus within the Japanese scientific community that the project is worth pursuing.

**(extracted with permission from an item by Michael Banks at physicsworld.com)**

## COVID-19: how physics is helping the fight against the pandemic

Even if molecules refuse to be crystallized, there is still the chance of obtaining structures using cryo-EM, a technique pioneered by Jacques Dubochet of the University of Lausanne in Switzerland, Joachim Frank of Columbia University in New York City, US, and Richard Henderson of the MRC Laboratory of Molecular Biology in Cambridge, UK, for which they shared the 2017 Nobel Prize for Chemistry. In a cryo-EM experiment, a solution containing the biomolecule or complex of interest is applied to a sample holder, or "grid", as a thin layer. The grid is flash-frozen in liquid ethane to vitrify the sample, which is then imaged by the electron microscope with low doses of electrons to minimize radiation damage. Because single molecules or complexes are imaged directly, there is no need for crystallization.

Thanks to cryo-EM, Daniel Wrapp and Nianshuang Wang of the University of Texas at Austin, US, and colleagues were able to obtain the structure of an outer "spike" protein of SARS-CoV-2 that is believed to enable

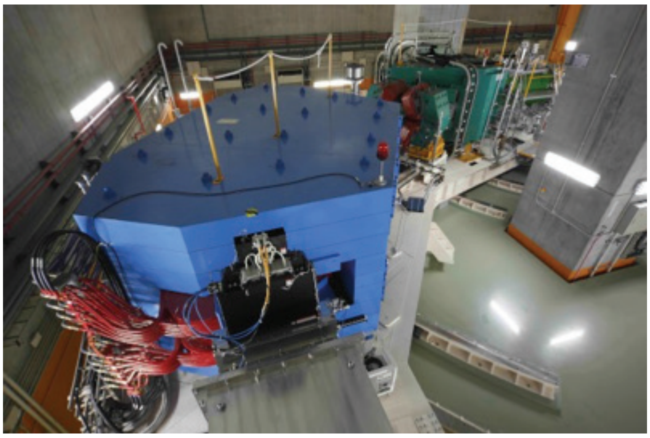
**Not pretty in pink - This painting depicts a coronavirus just entering the lungs, surrounded by mucus secreted by respiratory cells, secreted antibodies, and several small immune system proteins. (Courtesy: David S Goodsell, RCSB Protein Data Bank)**

the new virus to weasel its way into host cells. From harvesting the protein to submitting a paper to the journal Science on 10 February, the entire process took just 12 days (10.1126/science.abb2507). "Without cryo-EM," says the University of Texas's Jason McLellan, an author on the paper, "it may not have been possible at all."

The structure of the external spike is more useful for creating coronavirus vaccines than drugs. If host cells are exposed to virus-like particles that brandish the same external features, while being hollow inside, those cells can still help the body build an immunity but without the risk of being exposed to a dangerous, fully fledged virus. David Stuart – a structural biologist at the University of Oxford in the UK and director of life sciences at the Diamond Light Source, a "third-generation" synchrotron – has used this synthetic trick to create a new vaccine for foot-and-mouth disease. This virus, which is still devastating livestock in large parts of Africa, the Middle East and Asia, is in a family of single-stranded "positive sense" RNA viruses that also includes polio and human rhinovirus – the latter being behind most cases of the common cold. "Only in the past few years have we been able to exploit structural biology to understand immunity to disease," he says. The knowledge of viral structures can even be used to design synthetic "therapeutic antibodies" to directly attack diseased cells, he adds.

**(extracted with permission from an item by John Cartwright at physicsworld.com)**

## Valence proton could play a key role in oxygen neutron drip line anomaly



**Unexpected result: the SHARAQ detector at the Radioactive Isotope Beam Factory (Courtesy: RIKEN)**

Adding a single proton to a doubly magic isotope of oxygen is enough to significantly alter its properties, an international team of physicists has discovered. Led by Tsz Leung Tang at the University of Tokyo, the researchers made the unexpected discovery after removing a proton from a neutron-rich isotope of fluorine. Their work could lead to a better understanding of the complex interactions that take place between protons and neutrons within atomic nuclei.

Basic information about how protons and neutrons interact within a nucleus can be gleaned from a nuclide chart, which plots the numbers of protons in an isotope against the number of neutrons. The "neutron drip line" in such a plot shows the maximum number of neutrons an isotope of each element can contain.

One particularly striking feature of this boundary is the sharp jump in neutrons between neighbouring oxygen and fluorine, which has one more proton than oxygen. An oxygen nucleus (containing eight protons) can contain up to 16 neutrons, however fluorine can contain as many as 22 neutrons. The reasons behind this jump are poorly understood, but researchers believe it is related to oxygen-24's "doubly magic" nucleus, which contains extremely stable filled "shells" of protons and neutrons.

To explore the jump in more detail, Tang's team prepared a beam of the isotope fluorine-25 at the Radioactive Isotope Beam Factory near Tokyo – which is run jointly by Japan's national research institute RIKEN and the University of Tokyo. Fluorine-25 contains one more proton than oxygen-24 and can be thought of as an oxygen-24 core plus a single valence proton.

This latest research involved colliding fluorine-25 nuclei with a target to remove a proton. Using the SHARAQ detector, Tang and colleagues measured correlations between the motions of the collision products and found that around 65% of the resulting oxygen-24 nuclei were in an excited state. This is contrary to current theory, which predicts that the oxygen-24 core of fluorine-25 should exist in its lowest energy state.

This suggests that the addition of a single valence proton to oxygen-24 has a profound effect on the doubly magic core. Indeed, Tang's team concluded fluorine-25's excited core is likely responsible for the neutron drip line's dramatic jump – although the reasons why such significant changes can be driven by a single proton remain a mystery. The team now aims to uncover the physical mechanisms in future experiments.

**(extracted with permission from an item by Sam Jarman at physicsworld.com)**

## Hydrogel helps make self-cooling solar panels

Moisture harvested from the atmosphere at night by a hydrogel can be used to cool down solar panels during the day, boosting their efficiency. So say researchers at the King Abdullah University of Science and Technology (KAUST) in Saudi Arabia and the Hong Kong Polytechnic University (PolyU) who made the hydrogel from a mix of carbon nanotubes in polymers with a hygroscopic calcium chloride salt. The technology could be an environmentally-friendly way to increase photovoltaic electricity generation and also cool down other devices.

Solar photovoltaic (PV) panels currently produce more than 600 GW of the world's power, and this figure is expected to increase to 1500 GW by 2025 and 3000 GW by 2030. While solar energy is an abundant, inexhaustible and very clean energy resource, commercial silicon-based PV cells can only convert between 6-25% of absorbed sunlight into electric current. The rest is transformed into waste heat, which increases the temperature of a solar panel by up to 40°C. This makes the cells less efficient, and it can also damage them – especially in hot climates, where the problem is even more serious than in more temperate areas.

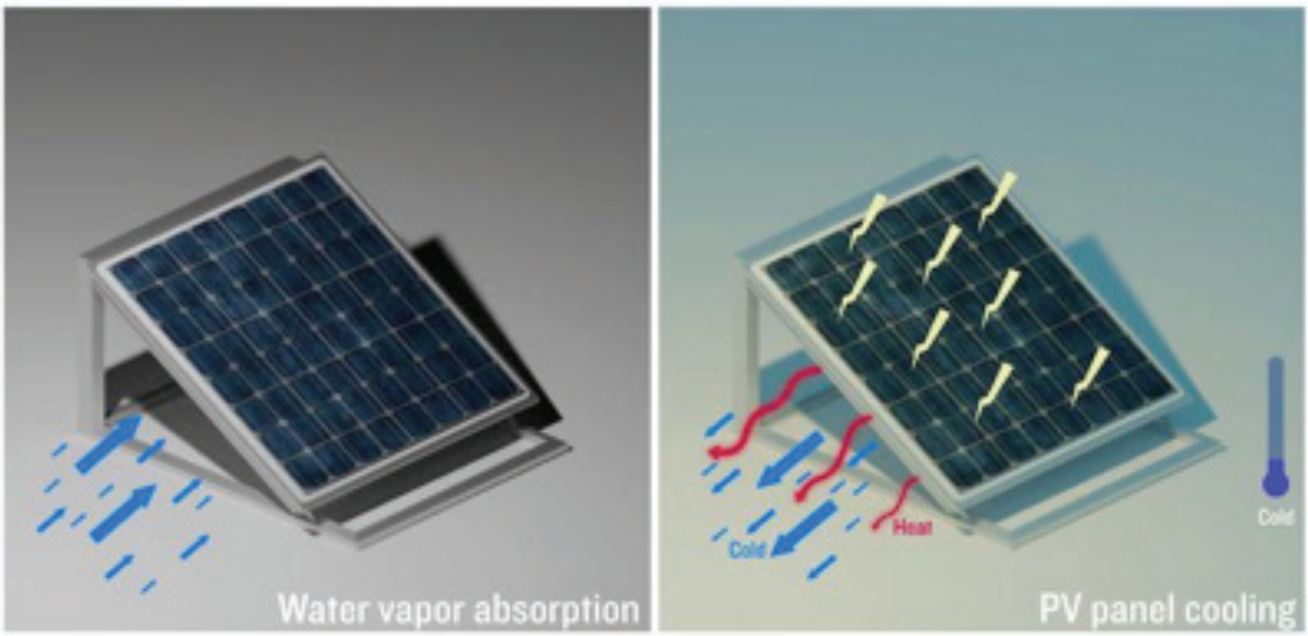
Current technologies to cool PV panels include refrigeration or air conditioning, but these can be energy-hungry. Water-cooling systems also exist, but they require abundant water supplies, as well as storage tanks and a complicated network of pipes and pumps.

**A gel-like material with a high affinity for water molecules**

A team of researchers led by Peng Wang of KAUST's Water Desalination and Reuse Center and the Department of Civil and Environmental Engineering at PolyU recently developed an alternative cooling method. Their technique is based on a gel-like material that comprises heat-absorbing carbon nanotubes (CNTs) embedded in a cross-linked polyacrylamide (PAM) and calcium chloride ($CaCl_2$). This gel has a high affinity for water molecules and can therefore take up large quantities of water vapour from ambient air. According to lead author Renyuan Li, the gel also has the ability to self-adhere to numerous surfaces, including solar panels, through strong hydrogen bonding.

In their experiments, the researchers pressed a 1-cm-thick layer of the hydrogel against the underside of a standard silicon solar panel. When the temperature drops in the evening and overnight, the water absorbed by the material condenses to form liquid water, explains Wang. During the daytime, as the temperature increases, the heat from the PV panel causes the water to evaporate – a process that not only removes heat from the panel, but also regenerates the vapour sorbent so that the atmospheric water harvester (AWH) is ready for the next night-day cycle.

**(extracted with permission from an item by Isabelle Dumé at physicsworld.com)**




**When the gel is fully filled with water, it can free enough water to reduce panel temperatures by 10 degrees Celsius. (Courtesy: © 2020 KAUST; Youssef A. Khalil)**

## Tracking elephant rumbles without breaking the bank

Although more famous for their trademark trumpet sounds, elephants also make loud low frequency vocalizations known as "rumbles", which extend below the range of human hearing. In a new study, a team of geoscientists has tracked the acoustic and seismic signals of rumbles among a family of elephants at a reserve in South Africa. They did this using a relatively low-cost sensor kit – showing promise as an affordable tool for wildlife studies and conservation projects.

In ecology, there is a growing understanding that monitoring animal sounds can reveal a lot about animal behaviour. At the same time, the increasing availability of cost-effective and scalable acoustic sensors is leading to a growing number of animal studies that make use of this technology. Tracking animals in this way also removes the need to physically tag them, which can be logistically difficult and stressful for the animals.

Elephants are big. Given the vast size of their vocal tracts, elephants can produce sounds that are loud and low – with frequencies below the 20 Hz limit of human hearing. As well as travelling through the air, this infrasound can also couple with the ground and propagate through the Earth as seismic waves. Earlier research, reported in Physics World, observed that the seismic component of rumbles could play an important role in long-range communication among elephant herds.

"There is evidence from previous studies that rumbles are used to coordinate movement and spacing of social groups, help individuals find each other, as well as triggering defensive or exploratory behaviour," said Oliver Lamb of University of North Carolina at Chapel Hill in the US, who led the latest study and presented it last week at EGU2020: Sharing Geoscience Online.

**Equipment costs – the elephant in the room**

Lamb's group set out to see if they could get meaningful results using an off-the-shelf device known as a Raspberry Shake and Boom (RS&B). Resulting from a Kickstarter campaign in 2016, the RS&B – based on the Raspberry Pi computer – is popular among educators and amateur seismologists due to its accessibility and cost. While conventional geophysical sensor systems tend to cost thousands of dollars, the RS&B seismo-acoustic is currently sold to researchers for approximately $865.

**African elephants at the Adventures with Elephants reserve in South Africa (Courtesy: Oliver Lamb)**

Lamb and his team took five RS&B units to study a family of seven African elephants at Adventures with Elephants – a 300 hectare area reserve in the north-east of South Africa. During a four-day period in October 2019, the group focussed on reunion events, which tend to involve a significant amount of vocalization. To calibrate readings, they also deployed a collection of more sensitive – but more costly – monitors.

To the researchers' surprise, the acoustic component of rumbles below 50 Hz was more clearly recorded using the low-cost device than with the more sensitive microphone. This extra information would be useful in ecology studies for distinguishing individual animals by age and size. On the down side, the acoustic range was limited to roughly 400 m, which would only be of practical use in locations where elephants are known to congregate, such as waterholes and food sources.

Unfortunately, the seismic range of the device was even smaller. Individual rumbles were detected to within 100 m, while elephant footsteps were limited to just 50 m. Describing their results in a paper submitted to Bioacoustics, the researchers suggest they could extend the range up to 1 km by anchoring sensors to rocks rather than burying them in the ground.

**(extracted with permission from an item by James Dacey at physicsworld.com)**

# PRODUCT NEWS

## Lastek

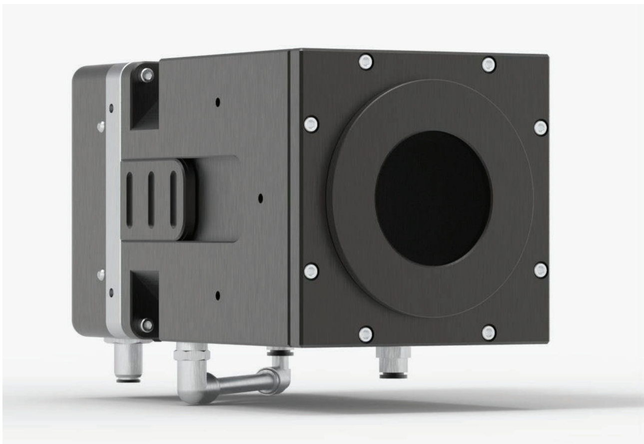
### 1. Thorlabs New High Speed Optical Modulator

Thorlabs' High-Speed Optical Modulators use deformable mirror technology instead of Pockels cells or acousto-optic modulators to provide high-speed intensity modulation and beam attenuation (see graph at right). The all-reflective design incorporates gold-coated MEMS mirrors that are polarisation independent and introduce minimal (<100 fs2) dispersion. This unidirectional device accepts a collimated, 1 to 2 mm (1/e2) diameter input beam with <5 W optical power and is available with either standard (>250:1) or high (>2500:1) contrast ratios.

Features:

- Offers DC Power Attenuation and High-Speed Modulation
- 700 nm to 1100 nm Operating Range
- <2 μs Response Time
- Polarization Independent
- External Photodetector for Monitoring/Calibrating Output Power
- (PDA100A2 Si Detector Included)
- Near-Zero (<100 fs2) Dispersion
- Passively Cooled to Eliminate Vibrations

### 2. ALIO Angulares Hybrid Hexapod: the most angular travel range available from any 6-Degree-Of-Freedom (6-DOF) positioner on the market



ALIO Industries has just announced the availability of its new AngularesTM Hybrid Hexapod®. The 60-degree tip/tilt travel of the AngularesTM Hybrid Hexapod® is by far the most angular travel range available from any 6-Degree-Of-Freedom (6-DOF) positioner on the market and offers the same unmatched positioning performance found in any of ALIO's full-line of Hybrid Hexapod systems.

The AngularesTM features precision crossed roller bearing guides, optical incremental or absolute encoder feedback on all axes, linear motor and/or servo ball screw drives, unlimited programmable tool centre point locations and coordinate offsets, and zero backlash on all axes. The design makes the AngularesTM capable of unlimited XY travel, Z travel for 62 mm which can be increased to 208 mm using other tripod models, tip/tilt travel of 60 degrees (+/- 30 degrees) with continuous 360 degree Theta-Z, XYZ bidirectional repeatability of less than +/- 0.6 arc-seconds, velocity up to 100 mm/second XY and Z, and less than 10 nanometers linear and 0.1 arc-seconds angular minimum incremental motion.

**3. Gentec-EO HP-125A-15KW: New high power detector for laser power measurement up to 15kW**


HIGH POWER HANDLING

Handles up to 15 kW of continuous power with standard models. Custom models available for higher powers.

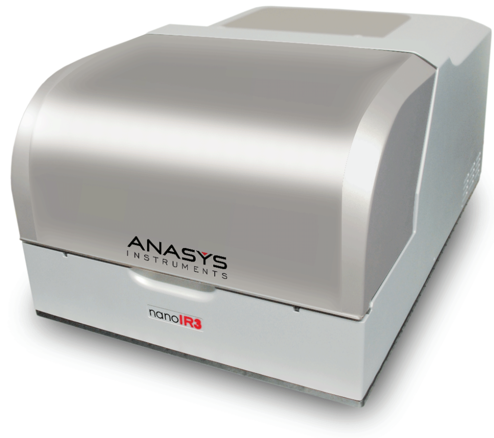
STABLE READING

Less sensitive to variations in water cooling temperature than any other high power water-cooled meter on the market.

- Maximum average power (continuous): 15000 W
- Minimum average power1: 500 W
- Noise equivalent power2: 15 W
- Spectral range: 0.193 - 20 μm
- Typical rise time: 15 sec
- Typical power sensitivity: 0.13 mV/W
- Power calibration uncertainty: ±5 %
- Repeatability: ±2 %
- Back reflections: 2 - 4

# Coherent

**Nanoscale Infrared Spectroscopy**

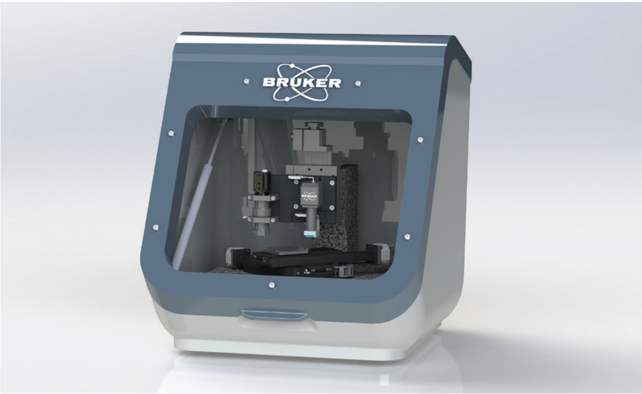



Combining the high resolution of Atomic Force Microscopy with the chemical analysis capability of FTIR microscopy, the new Bruker nanoIR3 provides chemical information at <10nm spatial resolution. By using the PhotoThermal technique pioneered by Anasys Instruments, researchers get targeted, site-specific IR spectroscopy covering the range from 670-4000cm-1 and chemical mapping with <10nm resolution. Spectroscopy results are fully correlatable to existing IR databases allowing convenient identification of unknown constituents.

This latest generation instrument improves core AFM performance while implementing new nanoIR techniques including Tapping-IR, Resonance Enhanced-IR, Hyperspectral-IR and FASTSpectra we well as other AFM techniques such as scattering-SNOM, Lorentz Contact Resonance imaging, scanning thermal microscopy and nanothermal analysis, combined into one instrument. The Bruker nanoIR3 is the world's most complete platform for nanoscale chemical imaging and spectroscopy in the pursuit of advanced materials research.

**For further information please contact:**
**Christian Gow**
**Coherent Scientific Pty Ltd**
**sales@coherent.com.au**
**www.coherent.com.au**

## New Compact Benchtop Solution for Precision Nanoindentation Testing




Bruker's latest nanoindentation instrument, the TS-77 Select brings high performance nanoindentation to a compact and cost effective benchtop package. Featuring the same high performance transducer and in-situ scanning technology as the TI-Premier and TI-980 Triboindenter, the TS-77 Select is the perfect solution for research and industrial laboratories requiring high precision hardness testing.

With the same core technology as the full size TI series solutions, the TS-77 Select can provide all the precision test capabilities needed for many fundamental research applications, including Nanoindentation, in-situ SPM imaging, Fast Property Mapping, 3D nanoWear as well as options for Nanoscratch and Dynamic Nanoindentation.

Designed with the end user in mind, the TS-77 Select maximises the sample space for its compact footprint, while allowing high levels of flexibility for users wanting to create their own test routines and loading profiles. Embedded in a streamlined user interface, the TS-77 Select provides automated system calibrations and automated measurement routines for easy execution of repetitive tests.

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ASSOCIATION OF ASIA PACIFIC PHYSICAL SOCIETIES

# AAPPS Bulletin

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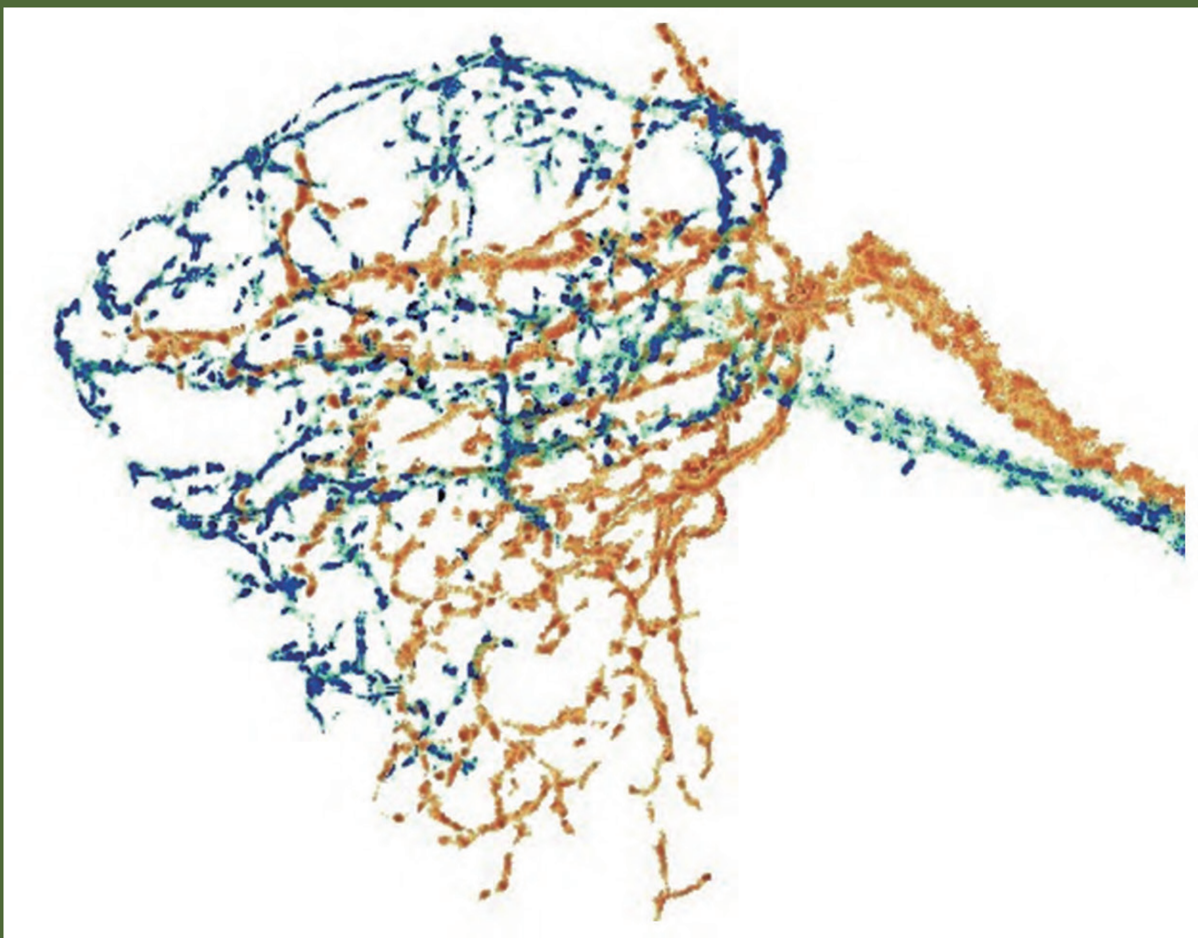
## Optical Microscopy Now Visualizes 3D Distributed Nerve Fibers in a Fly Brain





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