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VOLUME 59, NUMBER 3, JUL-SEP 2022

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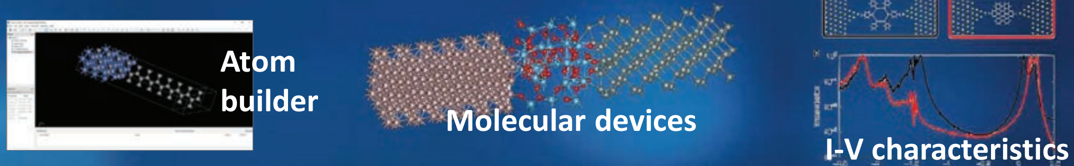

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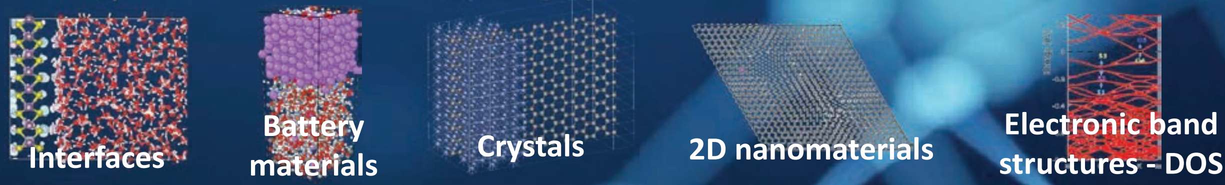

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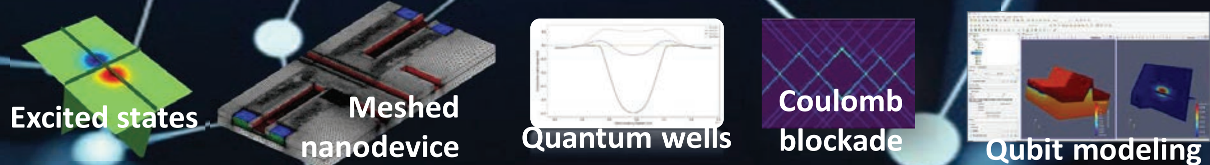

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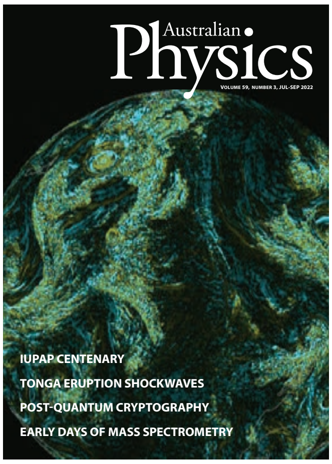

On 15 January 2022, shortly after 04:00 UTC, the Hunga Tonga–Hunga Ha'apa undersea volcano erupted in a very large explosion, sending an atmospheric shockwave travelling long distance around the planet. The image shows atmospheric water (mid-level water vapour, 6.9 μm), observed by the GOES-17 satellite, about 90 minutes after the explosion. The shockwave resembles ripples on a pond with the wavefront approaching the north coast of New Zealand, 1800 km away from the epicentre.

For artistic purposes, the colour scale of the original image was changed and the view was rotated 90 degrees clockwise; the equator now runs vertically through the image and New Zealand is visible at the top left (Australia is located just beyond the horizon).

For the full sequence of images see https://cimss.ssec.wisc.edu/satellite-blog/archives/44252 .

(images: Tim Schmit, NOAA/NESDIS/ASPB)

Australian Institute of Physics

Promoting the role of physics in research, education, industry and the community

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Editorial

Diversity in physics: past, present and future

This issue of Australian Physics showcases the past, present, and future diversity of Physics and physicists Australia.

Bruce McKellar and Peter Robertson reflect on the centenary of the International Union of Pure and Applied Physics (IUPAP), and Bruce's presidential tenure of the same.

We also share the stories of other fascinating physicists. J. Roger Bird built Australia's first mass spectrometer in 1947 and helped ignite many multi-disciplinary projects across Australia. Millie Maier and John Innis apply their physics passion and training to visual effects and air pollution monitoring, respectively. Nuclear physicist Herb Bolotin was an inspiring academic and leader with international and local impact.

Within the Asia-Pacific region, Kevin McCue and Bruce Boreham investigate the shockwave formation of January's Tonga volcanic eruption.

Looking ahead, advances in quantum computing are expected to require new encryption methods. A 2023 issue of Australian Physics will be devoted to quantum information technologies. We welcome any contributions on this theme.

The future of physics depends on the education of future physicists. Paul Looyen reviews a new book arguing for teaching Einsteinian physics across the school curriculum. We continue to seek articles from Year 12 students for publication.

Finally, we welcome Dr Shermiyah Rienecker who joins the editorial team, having collated the 'Physics Around the World' section for many issues.

Best wishes,

David Hoxley, Clara Teniswood, Shermiyah Rienecker and Peter Kappen.

From the Executive

Ethical banking

We are proud to inform our members that the AIP is in the final stages of moving our business to Bank Australia. This is part of the AIP's commitment to fight climate change and to contribute to a fairer world.

There are many things one can do to reduce carbon emissions, and we are convinced that many of our members are actively engaged in making our country more sustainable. Typical examples are using public transportation or a bicycle instead of driving, recycling, and reducing use of plastics. For academics and physicists in industry, one might consider reducing the number of conferences and meetings involving air travel and instead attend remotely where possible.

However, many people do not know about the most powerful leverage when it comes to climate action and sustainability: your saving accounts. After depositing your money in the bank, it joins a pool of funds that will be invested by your bank into anything that promises profit. Unfortunately, amongst those things are investments you would not necessarily agree with, for example, fossil fuels, gambling and weapons. Estimates indicate that Australian banks have invested tens of billions of dollars into fossil fuels in the last six years.

A solution to this problem is in 'ethical banking'. 'Ethical banking' refers to banks that guarantee not to invest into particular industries, such as fossil fuels. A list of banks which do, and do not, have a record of funding fossil fuels is available here: https://www.marketforces.org.au/info/compare-bank-table/.

The AIP National Executive has taken action and we are now moving our business to Bank Australia, which states that they have not, and will not, fund fossil fuel investments. As more individuals and companies move their money from banks that invest in fossil fuels, these banks will eventually be forced to re-structure their portfolio of investments to remain competitive.

Perhaps we can inspire some of our members to consider this aspect of climate action. Further information on ethical banking is available in this ABC article: https://www.abc.net.au/everyday/a-guide-to-ethical-banking-in-australia/11812864.

We would like to thank the member that raised this issue with us, as well as our Honorary Treasurer Judith Pollard and her team for the considerable work in making this move happen.

Stephan Rachel,
AIP Special Project Officer for Advocacy

Centenary of the International Union of Pure and Applied Physics

Peter Robertson
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In July this year IUPAP celebrated the centenary of its foundation in 1922. A number of activities have been organised, including a Centennial Symposium at the International Centre for Theoretical Physics in Trieste and a Photo Competition on the theme 'the beauty of physics'. Many of the activities have been combined with those of the 2022 International Year of Basic Sciences for Sustainable Development, given that the IUPAP's promotion of physics for sustainable development is a major part of its centenary celebrations.

IUPAP's Beginnings

IUPAP was founded in 1922 in Brussels with 13 member countries: Belgium, Canada, Denmark, France, Holland, Japan, Norway, Poland, South Africa, Spain, Switzerland, United Kingdom and the United States [1]. Australia became the 17th member, joining in 1925. Although its primary aim was to encourage and aid international cooperation in the field of physics, IUPAP was only partially successful during its early years. As retribution for WWI, the defeated Central Powers were excluded from IUPAP and it was not until after WWII that countries such as Germany, Austria and Hungary were granted membership.

The year 1922 was an interesting stage in the evolution of physics. The two hot topics were General Relativity, following confirmation in 1919 that starlight bends in the gravitational field of the Sun, and Atomic Physics which was closing in on the creation of quantum mechanics. It's interesting to note that in October 1922, Albert Einstein was awarded the 1921 Nobel Prize for Physics, while Niels Bohr was awarded the 1922 Prize.

The inaugural President of IUPAP was William Henry Bragg. After graduating from Cambridge University, in 1885 he was appointed professor of mathematics & experimental physics at the University of Adelaide. He later returned to England where he and son Lawrence were awarded the 1915 Nobel Prize for their development of crystallography (see Aust. Phys. 49(3), 75–79). Although he served for nine years as IUPAP President, it seems Bragg contributed relatively little to the development and growth of the organisation (indeed, two full-length biographies of him make no mention of IUPAP).

Over the years Australian physicists have played significant roles in IUPAP Commissions and Working Parties and four have been a Vice-President: Mark Oliphant (ANU), Walter Boas (CSIRO), Bob Street (UWA) and Bruce McKellar. By far the longest serving Australian is Bruce McKellar (Emeritus Professor, University of Melbourne). Bruce was the first Australian to hold the positions of President Designate (2011), President (2014), and Immediate Past-President (2017), totalling a remarkable 16 years of service to IUPAP.

In conversation with Bruce McKellar

Bruce, you have held a number of senior positions in Australian science, including Vice-President for Physical Science and Foreign Secretary of the Australian Academy of Science. I gather this is how you came into contact with IUPAP. Could you elaborate?

My role in the Academy had only an indirect influence on me becoming involved with IUPAP. In 2005 as Vice-President at Large, I happened to know the then President Designate, Alan Astbury, because of my visits to TRIUMF in Vancouver. I understood that Alan was seeking a Vice-President at Large from Australia, he consulted Tony Thomas (U. Adelaide), whom he knew well, and invited me to accept nomination as Vice-President at Large to be elected at the General Assembly of IUPAP in October 2005.

After my three-year term ended in October 2008, because of my position as Foreign Secretary of the Australian Academy of Science, I became the Chair, International Council of Science Regional Committee for Asia and the Pacific for three years. In this capacity I attended parts of the meetings of the Board of ICSU, and was asked to report on ICSU matters to

First prize in the IUPAP photo competition on the theme of the beauty of physics: 'Chasing ghost particles at the South Pole' by Yuya Makino (Madison, Wisconsin). The photo taken at the Amundsen–Scott Station features the Milky Way, the Aurora Australis and, in the distance, the IceCube Observatory, the world's largest neutrino telescope. Funded by the US National Science Foundation, IceCube came into operation in 2010 (credit: IceCube/NSF).

the Council of IUPAP, although I was no longer on the Council. This may have led to me becoming the President Designate of IUPAP in November 2011.

A long tenure

Did you have any idea your involvement with IUPAP would last so long – as Vice-President, as President, and now as the Immediate Past President?

I did not expect my time to continue after my term as Vice-President at Large. When I was asked to be President Designate in 2011, I expected to be involved until November 2020 – three years as President Designate, three years as President, and three years as Past President. However, the 2020 General Assembly was postponed until 2021, so I was Past President until then.

But then Kennedy Reed who took over from me as President, became seriously ill and had to resign in October 2019. Michel Spiro, the President Designate, became the President for the remainder of Kennedy's term, and was elected President in October 2021 for a three-year term, until October 2024. Because the immediate Past President, Kennedy, was unable to serve on Council, I agreed to act as the Past President on Council, but more to give advice and not to do so much work.

A busy President

What was your typical workload in a given year during your time as President?

While I was President the IUPAP office was in Singapore, and the workload was effectively 40 hours a week, and not 9 to 5. I was out of Australia at least every second month, and always organised flights to Europe and Asia to have a stopover at the Singapore office whether the flights were IUPAP related, for physics conferences or collaboration, or for family holidays.

My research of course fell away and I was publishing only about one paper a year, and that was more guiding the work of my co-authors rather than doing the work myself.

Bruce McKellar (left) presents the Inaugural IUPAP Medal for Outstanding Contributions to Physics in Developing Countries to Dr Jorge Flores Valdés from Mexico. The medal was presented during the IUPAP General Assembly held in Sao Paulo, Brazil in October 2017 (courtesy: IUPAP).

Major issues facing IUPAP

What have been the two or three major issues facing IUPAP during your time in office and how have they been addressed?

The current annual budget is about $US600,000 which goes principally to fund the IUPAP secretariat, sponsorship of physics conferences, travel costs, and funding the General Assembly every three years.

The first major issue was to stabilise the IUPAP budget, done while I was President Designate and President. That was addressed by insisting that we spend only within our budget, by no longer running deficit budgets, and by moving the office to Singapore, which gave us more support.

The second issue was a difficult situation with the International Union of Pure and Applied Chemistry on the cooperation between the two Unions in determining who discovered new elements. This was a time when new elements were made in experiments with nuclear accelerators and were so short-lived that it was not possible to do chemistry with them. I developed a close relationship with the then President of the IUPAC, and argued against physicists who wanted the chemists to have no role in the determination. We set up an acceptable way forward, and for IUPAP to play a significant role in the International Year of the Periodic Table in 2019.

In July this year UNESCO in Paris launched the International Year of Basic Sciences and Sustainable Development, with a range of activities through until July 2023. IUPAP has played a major role in planning the International Year and will share some of the activities with the IUPAP Centenary Celebrations. (courtesy: IUPAP)

Member Countries

There are about 60 member countries in IUPAP, which is less than a third of member countries in the United Nations. Is this because non-member countries have no significant physics research, or can't afford a membership, or both?

Both play a role in limiting the number of members. There is now an attitude that IUPAP can find ways of having members who find it hard to pay the membership dues, being driven by a Vice-President at Large with responsibility for membership.

As one example, Ukraine is the highest producer of physics research among all the countries who were not current members of IUPAP. We brought in Ukraine as a member, and waived their membership dues until further notice. We may bring in other countries by offering to waive their membership dues for the first three years. Or perhaps by establishing an Associate Member category where a country could afford a lower fee than a full membership. IUPAP is now trying to maximise the number of member countries, without worrying too much about total subscription revenue.

Past and Future Highlights

What achievements or developments are you most proud of while IUPAP President?

IUPAP has always been primarily a volunteer organisation with maybe one staff member. I introduced the concept that the Vice-Presidents should have a responsibility for a specific part of its operations. They are no longer a sinecure to add to your CV, but require you to work for IUPAP.

Where do you see IUPAP heading in the long term? Is the future rosy?

IUPAP is finding new things to do, and to do them properly will require more financial resources. I don't believe that the future is necessarily rosy. It will be hard work, and if it can be pulled off IUPAP will be much stronger and more effective.

Reference

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About the author

Peter Robertson is an honorary research associate in the School of Physics, University of Melbourne. He is a former editor of the Australian Journal of Physics (1980–2001) and of Australian Physics magazine (2010–12). Peter recently completed a book on how Australian radio astronomers were world leaders in this new science, over the period 1945–60: Golden Years of Australian Radio Astronomy – An Illustrated History (Springer, New York, 2022).

The Tonga Volcanic Eruption and Shock Wave Formation

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Bruce Boreham FAIP, Independent researcher – bruce.boreham@icloud.com

On 14 and 15 January 2022, explosive volcanic eruptions occurred on the uninhabited Hunga Tonga–Hunga Ha'apai island of Tonga in the SW Pacific about 65 km north of Tongatapu, the country's main island. Only the largest triggered an atmospheric shock wave that travelled thousands of kilometers as recorded on barometers at numerous weather stations. However, there is not yet a consensus on its cause. Here we postulate a possible mechanism for the strength of the eruption and the strong shock wave formation.

Introduction

Explosive volcanic eruptions are known to produce atmospheric shock waves [1]. However, they usually last for only a few seconds (i.e. travel only a few kilometres) [2]. A number of publications detail how atmospheric shock waves can be produced by the instantaneous venting of a gas at high pressure into a much lower pressure atmosphere (e.g. [3]). A shock wave will form at the boundary between the high- and low-pressure gas and will propagate supersonically into the low-pressure gas driven by the pressure differential. The shock wave is experienced as a large pressure discontinuity and the ratio of the pressures across this shock wave is defined as the shock strength [3]. Thus, in the case of an atmospheric shock wave, the shock strength increases with altitude (as the atmospheric pressure decreases with altitude, reducing the pressure in front of the shock).

The sudden release of high-pressure gas into the atmosphere will induce a shock wave independently of the eruption dynamics [1]. Unlike a sound wave, a shock wave does not travel with constant velocity. The velocity is a maximum at the initial stages of the eruption, decreasing with increasing distance from the source until it drops to the speed of sound (at which point it becomes a sound wave).

Large pressure waves can also be generated by a zone of very high pressure travelling at speeds approaching supersonic speed and these are also sometimes referred to as shock waves.

Discussion

Figure 1 shows the decay of the Tongan shock wave strength with distance at ground level (using measured values from stations in Australia, New Caledonia, USA and UK).

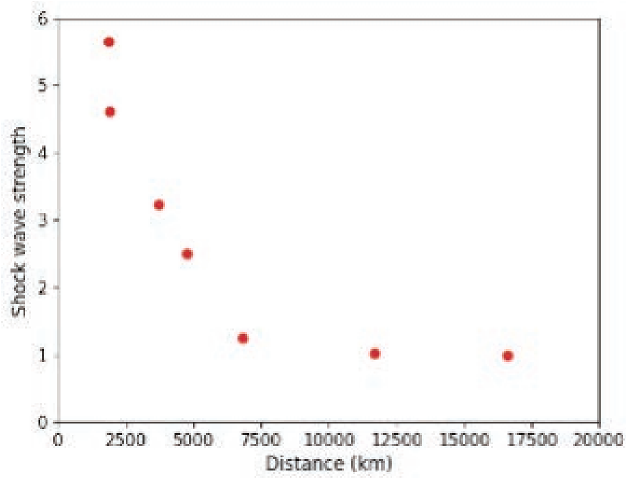


Figure 1: Shock wave strength measured at increasing distance from the eruption.

The shock strength varies as the inverse of the distance, as would be expected from geometric spreading, until it transitions to a sound wave at approximately 12,000 km from the eruption. This inverse variance can be used to calculate the shock strength as being 120 at a distance of 100 km from the eruption site. The corresponding Mach number, M, at this distance is M=10 (confirming this is a strong shockwave close to the eruption site, i.e. shock strength >50 and M >7.6). The Mach numbers are calculated from the Rankine-Hugoniot equation [3]:

$$\frac{P_2}{P_1} = 1 + \frac{2\gamma}{\gamma + 1}(M^2 - 1)$$

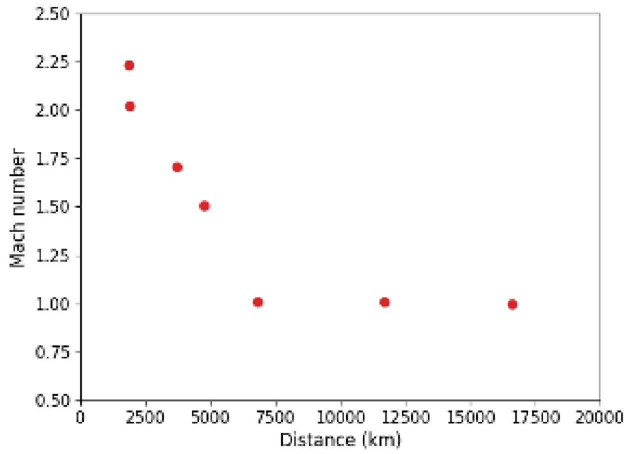


Figure 2: Shock wave Mach number at each measured distance from the eruption.

The Mach numbers corresponding to the measured shock strengths are shown in Figure 2. We see that the Mach number also falls rapidly with distance before transitioning to a sound wave.

The Tonga eruption was vertical, as shown on several video recordings, and the volcano acted like a vertical shock tube [4], with its interior acting as the high-pressure driver chamber. An instantaneous explosion and venting of high-pressure gas into the atmosphere could occur from a build-up of gas in the volcano. When the gas pressure reaches a threshold the volcanic plug shatters, releasing the high-pressure gas into the atmosphere and a shock wave may form. In the present case this process could have been enhanced by the injection of a small plug of red-hot magma into the chamber igniting flammable gas and triggering a large explosion that shattered the volcanic plug, venting high pressure gas and hot volcanic ash into the surrounding shallow water and atmosphere.

This release of high-pressure gas into the lower pressure atmosphere would cause a shock wave to propagate, driven by the initial high-pressure differential (the detonation overpressure). Simultaneously a tsunami was generated. The magma column rose vertically to an altitude of 58 km (https://www.bbc.com/news/science-environment-60088413) and collapsed horizontally covering surrounding islands in a thin blanket of ash. Two remnants of the caldera rim is all that remains of the island.

The energy, E, of the eruption can be calculated from the plume height, H, using the equation $E = (H/1.87)^4$ [5]. Assuming a plume height of 58 km, the corresponding energy is 925 PJ (218 Mt) or 4.4 times the energy of the explosion of the 50 Mt Tsar Bomba Soviet bomb detonated near Novaya Zemlya on October 30, 1961. (The Tsar Bomba explosion was 10 times the combined power of all the conventional explosives used in World War II).

This result is compared with the energy that generated the shock, E_S, calculated using the pressure V_s distance approximation for strong shock waves [6], i.e. $E_S = P_t r_t^3/0.115$. E_S = 1,103 PJ (325 Mt), where P_t is the transition pressure (in atm) and r_t is the transition distance (in km) (i.e. the pressure and distance at which the shock wave transitions to a sound wave).

These calculations for the eruption energy and the shock wave energy agree well to within a difference of 16%. Results obtained by [1] for similar calculations for five (less energetic) explosive volcanic eruptions varied from 23% to 92% difference with a mean difference of 75%.

We have found only two cases worldwide of natural shock waves travelling such large distances in the last nearly 150 years since barometers were widely installed: the devastating eruptions of Krakatoa in 1883, and now Tonga. Thermonuclear explosions (Hydrogen bombs) such as the Tsar Bomba generated similar phenomena [7].

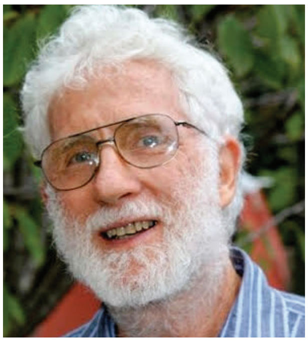
A theory has been advanced for the violence of the Tonga eruption based on the speed at which molten magna was blasted out of the volcano. When molten magma filled with volcanic gas is forced through sea water at high speed there is no time for it to be cooled by a layer of steam. This "fuel-coolant interaction" could cause a massive explosion (https://www.bbc.com/news/world-australia-60027360). This process could further enhance the chemical process we postulate which requires a combustible volcanic gas.

Where did the combustible gas come from? A recent paper suggests a model for us to speculate on the mechanism in this case [8]. The critical parameter is the island's location above an active, deep, long-lasting subduction zone. The abstract reads in part "Hydrous minerals in subducted crust can transport large amounts of water into the Earth's deep mantle. Our laboratory experiments revealed the surprising pressure-induced chemistry that, when water meets iron at the core–mantle boundary, they react to form an interlayer with an extremely oxygen-rich form of iron, iron dioxide, together with iron hydride. Hydrogen in the layer will escape upon further heating and rise to the crust, sustaining the water cycle" [8]. A detailed discussion of the state of the Earth's core is a later paper by some of the same authors [9].

Conclusion

Hydrogen produced at the core/mantle boundary reaches the surface under the island. Hydrogen is highly combustible. This mechanism explains how the shock wave was formed in this instance and how it was magnified by a simultaneous Hydrogen explosion. It could also explain why some volcanoes produce atmospheric shock waves and others don't.

About the authors



Kevin McCue has a Master of Philosophy degree in Engineering Seismology from Imperial College (University of London) and is a Fellow of the Institution of Engineers, Australia. He jointly founded the Australian Earthquake Engineering Society and, now retired from paid work, publishes widely in seismology with special interests in earthquake hazard assessments, tectonics, building codes and building response to earthquakes.

Bruce Boreham, now retired from paid work, was Professor of Physics and Head of the Department of Physics at Central Queensland University from 1989 to 98. He has a PhD from the Australian National University in Gasdynamics and is a Fellow of the Australian Institute of Physics. He has published widely in physics, environmental physics, engineering physics, physics education and more recently in philosophy of science.

Kevin and Bruce were students together in the ANU Department of physics shock tube laboratory in 1968.

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J. Roger Bird and Australia's first mass spectrometer

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J. Roger Bird was an accomplished scientist who built Australia's first mass spectrometer at the University of Melbourne in 1947. A 60° magnetic sector instrument, it was modified in subsequent years to improve its performance for the separation and collection of stable isotopes using a range of ion sources. Beyond Bird's seminal contribution to the birth of the field of mass spectrometry in Australia, he also made many important contributions to nuclear physics and archaeological applications, establishing and leading an accelerator mass spectrometry facility at the Australian Nuclear Science and Technology Organisation (ANSTO) in Sydney for almost three decades. This article provides overdue recognition for his role in early mass spectrometry in Australia.

With its widespread application today across many fields of science and medicine, it is easy for many to forget that mass spectrometry has its roots in physics. Ion beams formed within vacuum chambers, by means of electrical discharges, thermal ionisation, atom or ion bombardment, laser ablation or electrostatic sprays, among many others, are subjected to electric and magnetic fields as they make their way to an ion detector, producing currents that are digitised and then analysed.

As physicist Francis William Aston pioneered the field of mass spectrometry in Cambridge, England in 1919 [1], the Cavendish Laboratory's Director Ernest Rutherford realised its importance to many other disciplines and is said to have lamented that "the only thing faster than a (nuclear) transmutation, is the transformation of physicists into chemists" [2]. By the 1960s, mass spectrometry was widely used by chemists, and in the subsequent decades it was embraced by the biochemical, biomedical and clinical communities. Mass spectrometry now even offers an alternative analytical response to detect the pandemic viruses of our time [3,4].

Australia's First Mass Spectrometer?

The first mass spectrometer in Australia has been the source of some debate. The work of James D. Morrison at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) under Ian Wark on a newly installed commercial instrument in the Division of Chemical Physics from 1949, has often been regarded as the first application [5]. Morrison has even been referred to as the "father of Australian mass spectrometry" [6]. Morrison's own personal account, published in 1991 [7], gives credence to these events. It refers to the efforts of Ian Lauder at the University of Queensland and Peter Jeffrey at the University of Western Australia [8] to successfully build their own instruments in the early 1950s. In the same article, however, Morrison acknowledges that other machines had at least been projected at Melbourne University in the Department of Physics by a Dr. Bird, and in Chemistry by a student of Professor Buchanan. Morrison writes that he believed neither were completed [7]. This belief, however, contradicts published records.

At the 2009 biennial Australian and New Zealand mass spectrometry conference, held in Sydney and convened by the author of this article, the 60th anniversary of the field in Australia (1949-2009) was celebrated with Morrison in attendance among 175 other delegates (Figure 1). Prior to the meeting, this author located an abstract submitted for the very first such dedicated Australian mass spectrometry conference, also held

Figure 1: James Morrison with banner.

FIRST AUSTRALIAN CONFERENCE ON MASS SPECTROMETRY

AUSTRALIA'S FIRST MASS SPECTROMETERS?

J.R. Bird+
G.R. Hercus*
J. Cope*

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INSTRUMENTATION & TECHNIQUES GROUP - Fri., 27 August.
11-11:30 a.m.

In 1946, construction of a 60° Nier-type mass spectrometer was commenced at the Physics Department, University of Melbourne. This home-made instrument became operational in 1947 at about the same time that C.S.I.R.O. received a commercial unit. Difficulties with the former (such as low resolution and problems in filament replacement and emission stablisation) led to the development of an all-metal spectrometer which was completed in 1948. Several different ion sources were constructed and this instrument was used for a number of years as an isotope separator for the production of microgram quantities of isotopes of lithium, oxygen, neon, magnesium, zinc, etc. (for use in nuclear physics experiments). The C.S.I.R.O. instrument was a 180° type and was used initially for studying volatile organic molecules from such samples as milk and apples, as well as in measurements of ionisation efficiency and appearance potentials. Although extensively modified this instrument is still in use today.

Figure 2: Abstract from the first Australian Mass Spectrometry conference held in Sydney in 1971.*

(4) *Mass Spectrometer—Isotope Separation*
Worker: Mr. J. R. Bird.
The Nier-type mass spectrometer has been modified. The present instrument is all metal and has greater resolving power and pumping speed. Electronically stabilized power supplies are used to avoid drifts encountered with battery operation. Interchangeable ion sources make possible the measurement of isotopic abundances and also the separation of microgram samples of pure lithium isotopes. Separated isotopes obtained with this spectrometer are to be used as targets in experiments carried out with the million volt electrostatic generator.

Figure 3: Section from Physics Department in University of Melbourne Research Report 1948-49.

in Sydney [9]. It was reproduced as part of a poster presentation under the same title, complete with the question mark (Figure 2).

The abstract describes the construction of a 60° Nier-type geometry instrument within the Physics Department at the University of Melbourne in 1946, which became operational in 1947.

Further support comes from a Research Report of 1948-1949, published by the University of Melbourne, which describes the modification of the same instrument including the incorporation of interchangeable ion sources (Figure 3). The separation of isotopes of lithium is described; the instrument primarily intended to be used as an isotope separator over one for analytical purposes.

Bird builds his mass spectrometer

Born in Melbourne in 1927, Bird completed his Bachelor's degree in science in 1946 [10]. He then undertook the no small task of building a mass spectrometer for his Master's degree [11]. He was supervised by Professor Leslie Martin who had studied science education at the University of Melbourne and who had conducted his own Master's research on the emission of X-rays. Martin subsequently received an 1851 Exhibition Fellowship to study under Ernest Rutherford at the Cavendish laboratory. He was appointed a lecturer back at Melbourne in 1927 and rose to the rank of Professor by 1945, conducting nuclear physics research until the late 1950s.

Mass spectrometry was still in its infancy in the 1940s and the first of a few commercial instruments were just starting to appear. With the help of Mr. L. Hollow, the successful construction of the instrument in 1947 is a testament to Bird's considerable talents, even if some refinements were needed to improve its performance during the subsequent year. In Bird's Ph.D. thesis [12] he describes the instrument's construction, as well as improvements made for its application to the separation and collection of stable isotopes from a range of materials.

The 60° magnetic sector instrument (Figure 4) was constructed mainly of 16-gauge stainless steel, with a maximum available width for the ion beam of 9/16 inch (14.3 mm). Slits 3 mm wide were used to transmit an ion beam of the same diameter. The vacuum was provided using a two-stage backing pump and 4" oil diffusion pump, and a dry ice trap, that allowed operating pressures of between 10^{-5} and 10^{-6} Torr to be maintained.

The magnet was excited by a 1200 V, 200 mA power supply giving a maximum field of 5000 G (0.5 T). The mass-to-charge ratio for ions focussed with the maximum accelerating voltage of 2500 V was 100. The total accelerating voltage applied to the ion source was subdivided by a bank of potentiometers so that the various ion source electrodes could be connected to any intermediate voltage. The internal connections to the ion source were made via tungsten leads through glass seals to electrodes made of copper. These connectors that were readily disconnected to allow an interchange of ion sources.

A 10 V, 6 A filament supply and a 200 V, 100 mA supply provided the ion source power. The various circuits were AC-operated and electronic stabilisation was achieved

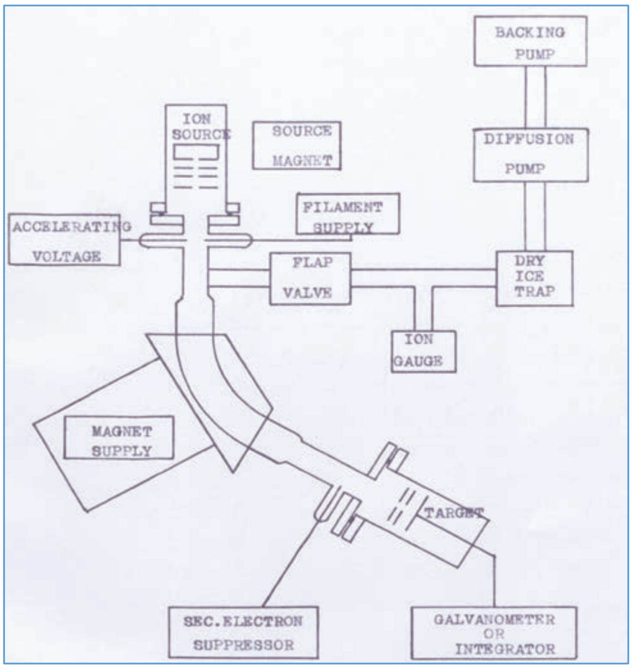

Figure 4: Block diagram of Bird's mass spectrometer [12].

by amplifying a portion of the output voltage to the grid of a tube, in series with the load. Fluctuations in voltage were better than 0.1%. The ion source power supplies were linked by a stabiliser which automatically changed the filament current to compensate for changes in either electron or positive ion emission.

The spectrometer tube was wide enough to allow ions diverging up to 8° to the central path to reach the detector. To control the angular spread, and improve mass resolution, a set of stainless steel baffles were placed inside the spectrometer tube from the source to collector. For the determination of mass, particles were focussed in a 6" radius of curvature.

Space charge effects were found to be small, although some defocussing was found when separating isotopes of metals due to the accumulation of metallic deposits on the walls of the spectrometer tube and the oxidation of these deposits. In order to counteract this, false walls were used in the central portion of the tube that could be periodically removed for cleaning.

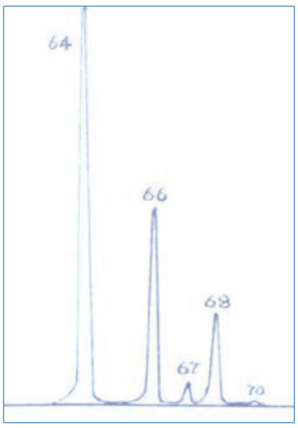

Figure 5: Mass spectrum showing the separation of the isotopes of zinc using a 2 mm source slit [12].

The mass spectrometer was applied to a range of applications and several spectra are provided in the thesis [12] showing isotope separation (Figure 5).

Among his many other later contributions to the field of mass spectrometry, Bird reported on measurements of the gamma rays on a time-of-flight instrument [13] and digital recording onto magnetic tape [14]. In 1989, he co-edited and contributed to a book on ion beams for material analysis [15].

Accelerator mass spectrometry at ANSTO

Roger Bird left for the United Kingdom in 1955 where he worked at the British Atomic Energy Research Establishment in Hartwell for almost a decade. He returned to Australia in late 1963 and joined the Physics Division at the Australian Atomic Energy Commission (AAEC) in Sydney; the predecessor of the Australian Nuclear Science and Technology Organisation (ANSTO). He championed the formation, and became group leader of, a new Accelerator Mass Spectrometry facility [16]. Here, he spent almost thirty years transferring his nuclear physics skills to other scientific fields. Bird was of particular help to archaeologists [17] in the dating of a wide range of materials including obsidian, pottery, bronze, aboriginal ochres [18] and prehistoric materials [19]. He is author of numerous publications, including several books [20], and was made a Fellow of the Australian Institute of Physics. He served as Editor of the Australian Physicist magazine in the 1970s.

Figure 6: Photo of Roger Bird ca. 1990 [17].

Bird's passing and recognition

Roger Bird retired in 1992 and died a decade later on November 22, 2001 at the age of 74. An obituary from The Age was reprinted in The Physicist in March 2002 [21]. Former Professor at Melbourne Tony Klein recalled "Roger was widely known for his work on analysis of materials in hydrology, chemistry and archaeology… (but mostly he) is fondly remembered by many colleagues as a brilliant and congenial physicist who made significant contributions to many fields of science, well beyond the confines of nuclear physics." It is fitting, too, that he also be recognised as Australia's first mass spectrometrist.**

Footnotes

*The conference evolved from that of the Vacuum Physics Group (VPG) of the Australian Institute of Physics. The VPG was formally constituted in December 1966. It held its first meeting in early 1968 with Marcus (Mark) Oliphant as a Guest Speaker.

**Perhaps Roger was destined to be a mass spectrometrist from birth. As well as referring to ions as being in "flight", the abbreviation BIRD is used for Blackbody Infrared Radiative Dissociation [22]; a term that describes ion-dissociation reactions caused by an ambient radiation field within ion cyclotron resonance (ICR) mass spectrometers.

About the author

Kevin Downard was awarded his Ph.D. in 1991 from the University of Adelaide in the field of mass spectrometry. He conducted postdoctoral research, and subsequently held an academic position, at the Massachusetts Institute of Technology in Boston. For over 25 years he has held professorial positions in the US (New York) and in Sydney, Australia where his research has focused on the development and application of mass spectrometry to improve responses to infectious disease causing viruses. He has published over 115 publications and two books on mass spectrometry and has received awards from both American and British mass spectrometry societies. He convened the 2009 biennial Australian and New Zealand mass spectrometry conference and has documented the history of mass spectrometry in Australia and has written on the field's early pioneers.

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Cryptography in the Post-Quantum Context

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On 5 July 2022, the United States National Institute for Standards and Technology (NIST) announced the conclusion of the third round of the NIST Post-Quantum Cryptography Standardisation Process. The development process for the considered algorithms was initially driven by Peter Shor's discovery of a quantum factoring algorithm in 1994 and has received additional impetus given the rapid pace of development of quantum computing. The resulting algorithms are intended to ensure that sensitive information secured today will remain secure against the threat of the emergence of general-purpose quantum computing in the future and are expected to be standardised by NIST by 2024.

Cryptographic algorithms and protocols are ubiquitously deployed around us to facilitate the operation of the modern world. They provide a range of unseen, but critical, trust and confidentiality services that we rely on every day. For example, an internet banking service must be confident in the identity (and continued identity) of a user and their authorisation to view or conduct a particular transaction, and must protect that information against disclosure to unauthorised parties. The user wants to be confident that the bank has correctly maintained the transaction history of the ledger, has not disclosed the transactions to another party, and has not allowed unauthorised expenditure of funds. Similar considerations apply to services such as medical information services (for example Australia's My Health Record system).

To achieve security in these systems, cryptographers deploy an array of cryptographic algorithms ('primitives') assembled into cryptographic protocols that are executed by each side of two communicating parties. In general, it is very difficult to specify and assure protocol designs leading to the use of standardised specifications such as Transport Layer Security (TLS, used for services such as web browsing) and Internet Protocol Security (IPsec, used for services such as Virtual Private Networks (VPNs)). Minor errors in specifications may lead to security issues discovered many years after protocol development (for example, the POODLE attack [1]). These protocols typically use *asymmetric* algorithms to agree on a small piece of cryptographic information which is then used to configure *symmetric* algorithms which perform the bulk data encryption and run integrity processes.

In the event of the construction of a quantum computer of a sufficient size, algorithms will need to be developed to be secure against these new machines. However, they will also need to retain their security against an attack mounted by an adversary with only access to classical computing. If this property is not satisfied, a hybrid approach must be used, and this can only be less efficient than using a single algorithm.

Hard Problems

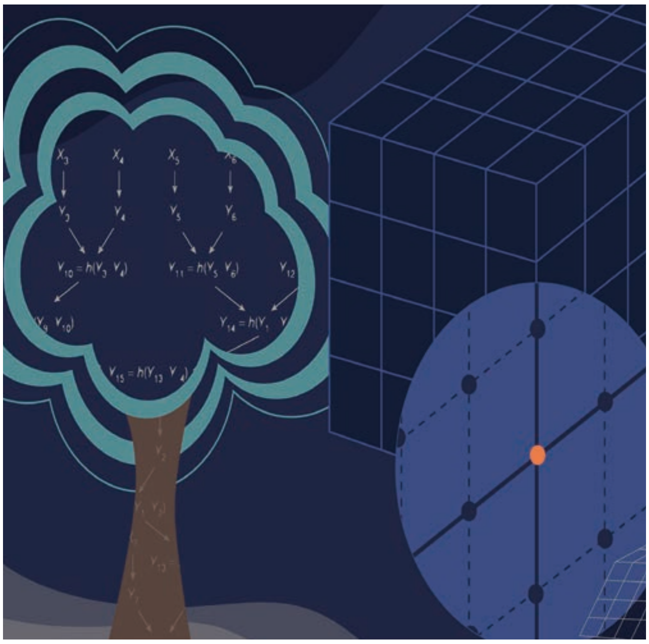
A cryptographically hard problem is a one-way function that has no-known efficient algorithm for recovering the inputs.

Consider multiplying two prime numbers together to create a semiprime. This function is simple to run in the forward direction, but there is no known efficient classical (non-quantum) algorithm for an adversary to determine the factors of this number. This problem is known as the *integer factorisation hard problem* and is the underlying idea for the Rivest-Shamir-Adleman (RSA) algorithm, which can be used to exchange small amounts of data suitable for configuring symmetric algorithms.

A second hard problem is that of determining the logarithm (base g) of a modular exponentiation operation ($g^x \bmod p$), which is known as the *discrete logarithm hard problem*. It is the foundation for the Diffie-Hellman (DH) process for agreeing on data subsequently used for configuring a symmetric algorithm.

The algorithms to be standardised by NIST use problems that are hard for both classical and quantum machines. For example, the CRYSTALS algorithms [2] for key exchange and digital signatures use hard problems in the construction of lattice objects to create one-way functions that can be used to construct cryptographic primitives.

The next stage of the development process for NIST is to create standards outlining data formats and mathematical operations in sufficient detail to allow implementation and interoperability testing. Some



Lattice objects are used to create one-way functions in the CRYSTALS algorithms. Credit: N. Hanacek/NIST [8].

discussion is underway in public NIST forums around optimisation of underlying functions to reduce the impact to computing speed (e.g. https://groups.google.com/a/list.nist.gov/g/pqc-forum/).

The Quantum Threat

If a sufficiently large quantum computer is developed, both of these hard problems will be brought undone by an algorithm discovered in 1994 by Peter Shor, subsequently known as *Shor's Integer Factorisation* algorithm [3]. While the current record of factoring the number 21 [4] comes nowhere near factoring values of the order used in modern algorithms (greater than 2^{2048}), there is a belief that much larger quantum computing systems are a substantial engineering challenge, but not a physical impossibility [5].

While symmetric algorithms are impacted by the development of a quantum machine capable of running Grover's algorithm [6], the impact is not severe as it can be mitigated by using existing algorithms that are already widely deployed. For asymmetric algorithms, the issue is far more severe and will take many years to rectify once the standardisation of new quantum-safe algorithms is completed.

Why now?

There are no quantum machines currently capable of performing the necessary operations at the scale required. Attempts to build larger quantum machines have not yet succeeded due to error accumulation (for example, failing to factor 35 [7]). Health data, personal records, and military information are examples of information that needs to remain confidential for multiple decades and that could be recovered by the emergence of a quantum machine. Whether this is tomorrow, 20 years, or 50 years into the future, it is time to start turning the ship on cryptographic algorithms and protocols so that we are prepared if, and when, these machines arrive.

About the author

James Porteous holds a Bachelor of Engineering (Electrical and Electronics) with First Class Honours from the University of Western Australia. He is currently working on high-speed data encryption and network security hardware for an Australian technology company.

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On receiving an AIP Award for Outstanding Service to Physics

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I was surprised and honoured to learn that the Australian Institute of Physics decided to recognise my contributions to the furtherance of physics as a discipline by presenting me with an AIP Award for Outstanding Service to Physics. I felt I followed a lucky trajectory in my physics career, and because of that I felt an obligation to do what I could to assist physicists to develop their careers and to assist in the development of physics itself. Initially I worked with an Australian focus, but I soon found myself able to play a global role, and worked to support physicists and physics around the world. I did physics along the way, but this award is about my support of physics and physicists and that is what I want to tell you about in this article.

After being on the old Australian Research Grants Committee (ARGC), which some of you may remember, I was invited to become a member of the inaugural Australian Research Council (ARC), also serving as the Chair of its Mathematical, Physical and Chemical Sciences Advisory Committee. In these roles I worked hard to ensure that Physics received a fair allocation of the available funds. In the newly formed ARC much time was spent to ensure that the system was working effectively. We had to rework the application and assessment systems, and push for policy implementations. With changing attitudes in the government, it required much persuasion, and involved wins and losses. A temporary win was that the assessor's numerical ratings for the aspects of the application were sent to the applicants. Although a small number of assessors refused to provide assessments under those conditions, I felt that the openness was important in our process. That was one of my innovations which disappeared as soon as I completed my term on the Council.

Towards the end of my term on the ARC the bureaucracy was pushing for the development of strategy plans for disciplines in Australia, and it selected Physics as one of the first to be developed. I was asked to work with the physics community to develop that plan, and became the Convenor of the Working Party of the National Committee for Physics for the Development of the Strategy Plan for Physics in Australia. With the support of the members of the working party, especially of the representative of the National Committee for Physics, Tony Thomas, the Strategic Plan took shape and was published in 1993. To the disappointment of some it set out priorities within the subdisciplines of physics but did not attempt to set priorities between the subdisciplines. Unfortunately, many of the recommendations were ignored by the authorities, but the recommendation that Optics be established as a priority area for ARC grants was accepted, because of the need to build up the discipline.

As the Vice President for physical sciences of the Australian Academy of Science I found myself working to ensure that all of the physical sciences, from Mathematics to Engineering and Applied Science received adequate recognition in the Academy. As the present-day trend to recognise and reward those whose work led to applications and industrial innovations was starting up it was vital, but difficult, to keep a focus on blue sky research. Then as the Foreign Secretary of the Academy I was particularly interested in ensuring that all of Australian Science was involved with the appropriate International Union, and that the Academy was working closely with the International Council of Scientific Unions (ICSU), later renamed the International Council of Science and now transformed into the International Science Council (ISC) after its merger with the International Social Science Council. For physics that Union is the International Union of Pure and Applied Physics (IUPAP). Australian Physicists have played significant roles in IUPAP and its various Commissions and Working Parties, but the relationship is highly dependent on the individuals involved.

At almost the same time that I finished my term as Foreign Secretary of the Academy of Science, I accepted an invitation to become a Vice-President at Large of IUPAP. At that time, the tradition was that the appointment was for three years only, and after my three year term, I was the liaison contact between IUPAP and ICSU. After three years in that role I became the President Designate of IUPAP, and in 2011 I became the first Australian President of IUPAP.

There was an understanding the number of members of IUPAP Commissions from a member country or region was to be equal to the number of shares in IUPAP the member held. In the years leading up to my presidency Australia had rather more than this, and it was quite a battle to maintain an excess. Australian Physics had much more international clout than would be suggested by the number of physics papers produced in the country, or the number of physicists working there.

Australia, like many of the IUPAP members, has found it increasingly difficult to find money in its budget to pay its dues to IUPAP, although its contribution to the world's physics publications suggests it should have rather more shares. I and many others have worked hard to ensure that Australia can find ways to keep up these payments — at one stage the Academy reduced its subscription to ICSU to be able to keep up its commitments to the many International Unions.

Three aspects are key to making these national and international activities productive:

1. The personal relationships that one develops with scientists and policy makers in Australia and around the world, and

2. The moral and financial support provided by colleagues, Department Heads and Vice-Chancellors.

3. The support of my wife Loris, particularly her forbearance of the long period I have been doing this work during my retirement.

I sincerely thank all who have supported me in this work, and the Australian Institute of Physics for honouring me with the Award.

#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.

Dr Millie Maier, Technology and Research Programme Manager at Weta Digital

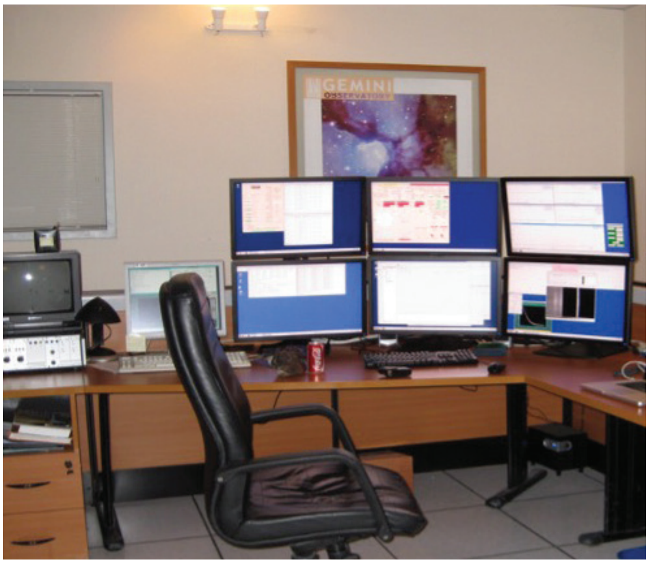
I manage research teams and their projects across several different departments at a VFX (visual effects or CGI) studio. There is plenty of physics involved from simulating physical phenomena and materials to the optics of light transport through a scene and camera hardware. VFX is a wonderful place for people who have studied physics and I really wish I had known about it sooner. There are plenty of interesting technical problems in this field and tons of everyday (often unexpected) uses for my physics knowledge or the technical problem-solving skills forged in the process of doing physics research.

From my experience as a manager, I would particularly encourage people to learn Python or C++ and strong coding best practices and object-oriented design. These skills are incredibly in demand at the moment (not just in VFX but everywhere) and when coupled with a physics degree, they open a lot of doors.

My career story so far:

I started my training with a Bachelor of Physics and Astronomy from Pomona College Claremont CA, The United States of America. Wanting to move onto somewhere new, I looked for PhD's abroad and was lucky enough to be offered a PhD (DPhil) position in Astrophysics at Oxford University, United Kingdom. I had a blast and learnt loads, inspiring me to go on in academia. I was then awarded the position of Gemini Science Fellow at the Gemini Observatory in La Serena Chile. It was my first post-doc at a large astronomical observatory where I got to observe the stars for many blissful nights-on-end in the Chilean Andes!

Having met some amazing Australians in Chile, I decided to move to the Southern Hemisphere. I won the coveted position of Super Science Fellow at Australian Astronomical Observatory in North Ryde, NSW. I then



went on to work as an Astronomer and Educator at Sydney Observatory, NSW.

My first job outside of astronomy was at a tech company (Atlassian) in Sydney, where I joined the design organization and sat in my first ever meeting that didn't involve charts and plots and math. I was excited to use problem solving skills, critical thinking skills, and systems-thinking from my physics background in a totally new context. I have hugely benefitted from learning about design thinking and meeting all kinds of new colleagues. Deciding to stay in industry I migrated overseas to an exciting new country at the offer to be a Research Programme Manager at Weta Digital - Wellington, NZ, where I am now.

Dr John Innis a Senior Scientific Officer, Air Monitoring at Environmental Protection Agency (EPA) Tasmania

John enjoying outdoor work in Tasmania

I co-ordinate Tasmania's ambient air pollution measurement programs. This includes working with instruments and data analysis, reporting and interacting with a range of stakeholders (including the public), contributing to national work programs through various committees, and some strategic planning.

My career story so far:

I initially completed a B.Ed.(Sci) in 1981 – a four year science teacher training degree at what was then called Melbourne State College (now part of the University of Melbourne). Then decided I wanted to keep studying. I was fortunate to be accepted into the Honours year in physics at Monash University and then completed a PhD there – both with a speciality in observational astrophysics. I had two really good supervisors: Keith Thompson and Denis Coates. Any problems that Keith couldn't solve on the back of an envelope or with a graph pad (and sometimes a slide rule!) Denis would logically 'nut out' in an overnight mental batch-process. I gained great insights into how to tackle physics problems from Denis and Keith. I had access to the Monash Observatory near Emerald and travelled to Siding Spring and Mount Stromlo.

After my PhD I did a term of teaching back at Melbourne State College then had a short stint at CSIRO Radiophysics in Sydney (and got to use 'the dish' for a week). Then I started a post doc in stellar seismology and exo-planets (in the days before any had been discovered) at the University of Birmingham, UK with a remarkable physicist and wonderful gentleman named George Isaak. That was a lot of fun (and hard work). I stayed on for a second post doc and learnt an enormous amount from George and the group there. We used telescopes in South Africa, the Canary Islands, and even back in Australia. We didn't have any clear detections of acoustic oscillations in stars (except for Arcturus) nor find any exo-planets, but I think we really explored the limits of technology and contributed a bit to the field in the early days. It's also been fascinating to watch the transition of this field from 'fringe' to 'mainstream' astronomy. A few years after I left Birmingham, George received both the Hughes Medal of the Royal Society and the Herschel Medal of the Royal Astronomical Society.

I then decided I wanted to return to Australia. Luck was with me as I managed to fulfil a long-standing hope and was selected by the Australian Antarctic Division (AAD) to be the upper atmosphere physicist at Mawson station, Antarctica, for 1993. As it turned out, that was the last year there was a wintering physicist position there and also the last year there were dogs on station. It was a remarkable year with a remarkable group of people. I had a research program studying the thermodynamics of the high-latitude thermosphere, as well as running instruments for other projects. I found I could transfer a lot of the experience I had from measuring stellar atmospheres to the work on the Earth's atmosphere – but also I had a lot to learn in the new field. Again, it was my colleagues, Pene Greet at the AAD, and Peter Dyson at Latrobe, who led me along the way. The Antarctic bug had then completely bitten – my wife, Petra (a glaciologist) and I wintered Davis station in 1999. We then moved to Alaska for two years as Petra had work there.

In 2002 we both found employment in Hobart. I re-joined the AAD in the atmospheric LIDAR project. I called on my astronomy background to design the optical receivers for two commercial telescopes and spent two further summers at Davis station. At the expiration of that contract in 2007 I counted myself very fortunate to obtain a fixed-term one with what became EPA Tasmania, working on the measurement of air pollution.

I'm still there. Our main air pollutant is smoke – mostly from residential heating in winter but also from bushfires and planned burns. With my team, we've substantially increased the measurement-base of air pollution data by going from two ambient air monitoring stations in 2007 to 35. Our real-time air network now extends over a significant part of the state, and is an important information source for the public, and for public health responses. We've also developed new analysis tools and new ways to understand and communicate the data. Underlying this has been a very strong physical-science base and a scientific approach. Other Australian jurisdictions have directly adopted some aspects we pioneered in Tasmania. This contributed to their ability to respond to the Black Summer bushfires.

Bringing a strong physics background and experience in measurement and data analysis to air quality work has significantly reshaped the way we view air pollution in Tasmania. There are still knowledge gaps and other issues to be addressed, but the ability we have now to provide hard data and comprehensive analysis to these problems has been almost revolutionary. I am hoping the approach we have taken will have influence for some years to come.

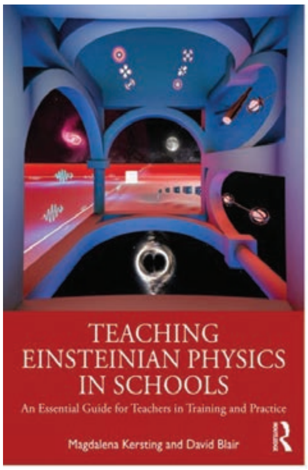
In 2019 John received the Clean Air Medal, the highest award of the Clean Air Society of Australia and New Zealand (CASANZ), which is the peak body for Air Quality professionals in Australia and New Zealand. Photo above is of John with the award.

Einsteinian Physics in the Classroom – a book review

Teaching Einsteinian Physics in Schools: An Essential Guide for Teachers in Training and Practice.

Magdalena Kersting and David Blair, Routledge (2021), 450 pages; ISBN: 9781760877712.

Reviewed by Paul Looyen, Faculty Head of Science, Macarthur Anglican School; Content Creator, Physics High, plooyen@macarthur.nsw.edu.au



1905 was a life-changing year for Albert Einstein. Often referred to his “Annus Mirabilus”, or miracle year, it was the year he published four ground breaking papers: the photoelectric effect; special relativity; general relativity; and his famous equation $E=mc^2$. Very few are left untouched by the implications of the principles that Einstein laid down in 1905, superseding the scientific understanding that existed before him.

It is ironic that today’s students of physics, at least at the school level, do not learn about Einstein’s contributions. If they do, this only occurs in their final years of schooling. It is not until students enter university that they truly explore Einsteinian physics at a greater depth.

The key question is “why?”. A common response is that Einsteinian physics is believed to be too complex for school students to fully grasp.

To challenge this perception, Dr Magdalena Kersting and Professor David Blair, with years of physics educational research between them, and a deep knowledge of Einsteinian physics published “Teaching Einsteinian Physics in Schools”.

Dr Kersting is an educational researcher and physics educator, based at the university of Copenhagen, Denmark, and has published numerous peer reviewed papers on effective physics education. Professor Blair is an experimental physicist based at the University of Western Australia. Prof Blair’s pioneering work underpinned the precision of LIGO to allow for the first detection of gravitational waves in 2015 and he was instrumental to the establishment of Australian International Gravitational Research Centre in Western Australia.

Both have a passion for Einsteinian physics education, seeing it taught right across the school curriculum. Their thesis: not only can Einsteinian physics be taught in the school at a conceptual level, it should be taught to students right across their schooling.

Their argument can be summarised as follows. Einsteinian physics not only gives students a more accurate model of the nature of the universe, but allows for teaching concepts in an innovative and interesting way, engaging and helping them better understand the world they live in.

The book is not one long discourse on the need for teaching Einstein physics in the classroom. Instead, it is written in such a way that it only provides strong arguments for the inclusion of Einsteinian Physics at the school level, but provides practical resources to support educators who wish include the relevant concepts in their classrooms

The book is divided up into three sections. The first section lays the groundwork for the rationale of teaching Einsteinian physics in the classroom, including why relativity was left out of schools’ curricula in the 1940s and 50s.

The next section, the crux of the book, the authors proceed to introduce each of the key concepts involved in Einsteinian physics - Special Relativity, General relativity and Quantum Physics, providing a primer (or review) for the reader to understand the concepts at a conceptual level. This is followed by a variety of activities and lesson plans to help teach those concepts at an appropriate level for the classroom, be that in the primary classroom or in the secondary classroom. Throughout it all, important principles in science education are discussed: how science works as well as the language of science.

In the third and final section, numerous case studies are provided from around the world where Einsteinian physics has been better integrated into the science curriculum. This highlights what the authors argue: their thesis is not based on academic research alone but on classroom tested pedagogy in a variety of countries and contexts.

Although the book has their names on the cover, it's more accurate to say that Dr Kersting and Prof Blair edited the book. While they contribute a significant portion of the book, there are 30 authors who have contributed to various chapters: experts in their field, whether it be in physics or educational research, or both.

One key benefit of the structure is that it need not be read sequentially. The reader can advance to a chapter or chapters that are pertinent or of interest to them. So, for example, a teacher may wish to embed a discussion of the photon in their lesson on light, and so may turn to the relevant section to not only review the concepts but access useful activities to teach the topic. To improve accessibility, each chapter provides a summary of what it intends to cover and to whom it intends to speak. A conclusion is also provided that summarizes the key points and includes resources for further reading and references is also provided.

So are their arguments convincing?

Prior to reading the book I admit I was of the view that Einstein's work is conceptually challenging, too challenging for younger students, and therefore more appropriate to be taught in the last years of high school. The book has modified my views.

There is a place for teaching Einsteinian physics in the younger years. I have been persuaded that there are many Einsteinian physics concepts that can be introduced in the classroom at the appropriate level, relating to their own experiences and can be introduced without cognitive overload.

By introducing better scientific terminology and teaching students about how models in science are developed, they will be better equipped to engage in science in the later years.

The intent is not that students develop a thorough knowledge of Einsteinian physics. There is always more to learn. The ultimate goal is to engage the students in science and, specifically, modern physics, whilst developing an Einsteinian literacy, all of which underpins the experiences they have in their lives.

However, there are some caveats. Teachers ensure what they convey is appropriate to their students' cognitive level. They won't teach field theory to Year 3 students! If new concepts are to be introduced in the classroom, first and foremost, two questions must be addressed:

1. Is this something they CAN understand?

2. Can it be expressed in ways to HELP them understand?

The authors recognise this. Activities are age appropriate and language terminology is introduced that younger learners can understand. A good example provided by the authors is how to refer to the wave and particle-like nature of the photon. The terms of "wavy like" and "bulletness" adequately describe those features to a younger student.

Second, it needs to be recognised that Einstein Physics is not easy at a conceptual level. It often isn't; much of it is counterintuitive and challenges preconceived notions. It therefore must not be rushed.

(The reality is that much of classical physics is just as challenging. I still meet Year 10 students who don't grasp Newton's Third Law and believe gravity stops once you are in orbit!)

As I read the book, I found myself reading slowly; pausing, thinking, and reflecting on what was written. This is how Einsteinian physics needs to be taught. Slowly, appropriately paced, to allow students time to think and critically process the concepts that are taught. The added benefit is that this encourages the students to develop critical thinking skills.

There are other constraints. The authors would like to see more Einsteinian Physics in the curriculum, but at what expense? Much of the curriculum that is taught is determined by the various government jurisdictions, and is often content dense. Where do teachers find the time to teach Einsteinian concepts if they are not specifically written in the curriculum? If new content is to be introduced, would something need to go?

A possible solution is to teach smarter. Rather than replacing, teachers modify how they teach certain topics. Gravity is often first taught in Year 7. Light is covered in Year 9. Activities that introduce Einsteinian concepts can be included, not to replace content, but to introduce alternate models.

But this leads to another constraint. Often, it is the physics teachers who will have a good working knowledge of Einsteinian concepts and can help students understand them. This is not necessarily the case. Many science teachers do not have expertise in physics, and this is even more likely with primary school teachers, who may not be science trained at all.

How effective are those teachers at conveying Einsteinian concepts if physics is not their strength? Teachers will only be convinced to implement the concepts if they themselves are confident in their own understanding of those concepts.

So how do we address this lack of expertise? The authors understand this, demonstrated by the fact that a significant proportion of the book is devoted to reviewing the concepts at a conceptual level. However, they also acknowledge that more has to be done in providing professional development to train teachers in Einsteinian physics.

Who should read the book? First, it is a valuable resource for teachers of all sciences, especially those in high school, and not just physics teachers. Any teacher who is passionate about improving the scientific literacy of their students and helping them develop an intuition for science should have this as a reference. Apart from deepening the understanding and historical development of physics concepts, the book presents a variety of interesting and engaging activities to implement in studying physics concepts in the classroom. As stated previously, this can be referred to multiple times as a reference as teachers look for ways to teach Einsteinian concepts. Who would have thought that you could bring out your Nerf guns and ping-pong balls to show how the photoelectric effect occurs!

Second, this is an excellent book that provides a review of Einsteinian physics in an accessible way for anyone interested in modern physics. Although the target audience is teachers and not necessarily the general public, anyone with a good understanding of high school physics and general science should be able to deepen their knowledge of the work of Einstein. The descriptions and explanations provided to topics such as the photoelectric effect, general relativity, and other aspects of modern physics are predominantly conceptual. There is some mathematical analysis provided but it is kept at a minimum. And when the mathematical analysis is provided, it is placed in boxes so the reader could choose to refer to it or continue reading the main text.

This book isn't going to radically skill up all teachers of Einsteinian Physics and nor is that its aim, but even if it helps the teacher implement a small change in the way that they teach science, students benefit by having a better understanding of the world they live in and of how science works.

About the reviewer

Paul Looyen is the Faculty Head of Science and Agriculture at Macarthur Anglican School, NSW. He has over 28 years Physics teaching experience in both government and independent schools, as well three years in the USA. In 2019, he was one of three teachers selected to attend the International High School Teachers Conference at CERN, in Switzerland, a highlight of his professional career. He also runs a popular YouTube channel, called PhysicsHigh, used by students and educators from around the world, which aids in understanding and communicating physics, pitched at a high school level.

Remembering Professor H. H. Bolotin

Andrew Stuchbery
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Herb Bolotin was an excellent physicist and educator with a sense of fun and unique humor. He came to Australia as the Chamber of Manufacturer's Professor of Physics at the University of Melbourne in 1971, a position he held until retirement in 1995. He established nuclear structure research using the new 5U Pelletron accelerator in Melbourne, and his group became regular users of the 14UD Pelletron Accelerator at the Australian National University (now part of the Heavy Ion Accelerator Facility). Upon "retirement" in 1996 Herb changed direction and worked successfully on bone densitometry as Emeritus Professor at Melbourne and then as Adjunct Professor at RMIT. He published in this field until 2009. He died suddenly on July 8th 2020.

Figure 1: Professor H. H. Bolotin.

Herbert Howard Bolotin was born on January 11, 1930 and grew up in New York. He was educated at Stuyvesant High School and the City College of New York (now C.U.N.Y.) – both selective institutions – which specialized in teaching physics, chemistry and mathematics. After he graduated in 1950, he married Charlotte Pearlman in 1951, and was selected as a post-graduate student at Indiana University. He was motivated by the elite scientists there who had worked on the Manhattan Project and were abreast of the newest research and techniques in nuclear physics. He completed his MSc and PhD in 1955.

After graduation he worked for the U.S. Naval Radiological Defense Laboratory (San Francisco); realizing he preferred academia, he held research positions at Brookhaven National Laboratory, Michigan State University, and Argonne National Laboratory. In that period of time, his son Andrew, was born in 1956, and his daughter, Allison in 1960.

After arriving in Australia as Professor of Physics, (Chamber of Manufacturer's Chair), at Melbourne University in 1971, Herb helped to establish the Melbourne Pelletron Laboratory. He pushed to obtain a PDP computer for data acquisition, a progressive step at this time. (A similar computer is shown in the film, "The Dish".) This computer not only supported nuclear structure and nuclear astrophysics research but enabled the development of X-ray imaging with the Melbourne Microprobe. The Pelletron laboratory continues today, featuring microprobe beam lines, and performing materials research. Using this new accelerator, Herb focused initially on measurements of the lifetimes of excited nuclear states using Doppler shift methods. Around 1980, he initiated a program to measure excited-state magnetic moments using the newly developed transient-field technique, and his group became regular users of the 14UD Pelletron Accelerator, now part of the Heavy Ion Accelerator Facility at the Australian National University: aspects of that activity continue today.

When lecturing to undergraduates and Honours students, Herb was clear and methodical. His humor, sometimes puzzling to Australian students in the 1970s, punctuated the lectures. For example, a lecture introducing Gauss's Law would invariably contain, "Mr. Gauss says … and by the way, Mr. Gauss is dead." On one occasion Herb asked the class whether the parity of a particular quantum state must be positive or negative. A student took a guess, "Negative?" Herb's response: "Close!"

In a light-hearted moment earlier in his career, Herb had a draftsman put a miniature representation of a lake with a sea serpent into a dip in the drawing of a nuclear decay scheme being submitted for publication. He hoped to sneak it past the referee and editor – but it was spotted! Herb was advised that the paper was accepted for publication subject to the removal of the sea-serpent and lake from the figure. In principle, only the editor and referee should have known about this. But somehow the word got out! For some time afterwards, physicists meeting Herb would ask if he was the "Bolotin of the sea-serpent"? Thus, the joke was shared and enjoyed widely.

Herb had a high regard for the excellent and hard-working graduate students he attracted. With characteristic humor, this regard was usually conveyed by reminding them that they were "slaves" and urging them not to "keep bankers' hours". As a graduate student, writing a paper with Herb was always both an education and a battle over the choice of words and punctuation. The student always lost – except, perhaps, when suggesting the insertion of a semicolon!

Herb was an outstanding mentor, providing opportunities and upholding high standards, always prepared to invest in equipment and infrastructure for research. He sought out and devised clever experimental techniques that helped minimize the possibility for systematic error. Herb had a critical eye to identify where something was going wrong, and a knack for picking topical and important research directions. One example was to measure the lifetimes of excited states in the nucleus platinum-196 [1] just as it was being proposed as the prime example of the novel O (6) limit of the new Interacting Boson Model, which took the nuclear physics world by storm in 1975.

Herb was commissioned by The Age newspaper in Melbourne, to write a series of articles on any aspect of his field that he found interesting. One of these, entitled "Nuclear Weaponry Self-Taught" was reprinted by the New York Times (December 26 1974). It is available online [2] – a good example of much truth being shared in jest.

Herb's high-quality research using Australian accelerators gained an international profile. As a consequence, he was the first overseas Professor to be invited to do research for 3 months at the new Research Centre for Nuclear Physics at Osaka University, 1977. Later he was invited to Rutgers University (USA), University of California Berkeley (USA), Padua (Italy) and London (UK), where he engaged in research, lectured and mentored students.

In the early 1980s he was invited to give a lecture tour in China by a senior Chinese physicist who felt that his younger colleagues were not keeping up with new ideas and techniques in nuclear physics. Three decades later, while visiting Beijing in 2012, Andrew Stuchbery met Chinese physicists who remembered those lectures.

In 1973, Herb became a member of the Royal Society of Victoria. In 1989, he received the Research Medal from the Royal Society of Victoria; he became a Foundation Fellow in 1995, and later served as its president from 1997-1998. He was elected Fellow of the Australian Institute of Physics (AIP) in 1971. He served as a proactive chair of the Victorian branch of the AIP from 1977 to 1978.

Nearing retirement age, Herb realised he would not be able to mentor a new intake of graduate students at Melbourne University. At this stage, a physician friend drew Herb's attention to the need for a sound floor of physical research under the field of bone densitometry. While winding down his nuclear structure activities, Herb became increasingly interested in this new discipline.

In 1996, as Professor Emeritus, he left Melbourne University, and accepted the post of Adjunct Professor at RMIT Bundoora Campus to work in bone densitometry. The strong leadership of the Chair of Medical Sciences there fostered an atmosphere of collegiality that helped Herb develop his new research focus. Herb's close study of their bone phantoms (models), along with ongoing reading, and speaking to a range of medical friends, soon meant he was able to contribute to this discipline. Over the coming decade he contributed 19 publications including some very well cited papers.

An important example was Herb's seminal paper in the journal *Bone* in 2007 [3], which described significant errors in the DXA (dual-energy x-ray absorptiometry) measurement of bone mineral density with changing body compositions. This work led to more caution in the interpretation of DXA results, helped motivate the development of new technologies in the measurement of bone mineral density, and continues to be cited in 2021.

It is no surprise that Herb's articles on bone densitometry brought the perspective of a rigorous physicist, and focused on experimental methodology, accuracy and scientific procedure.

Herb consistently received ARC grants to support his nuclear structure research, and won NHMRC funding for his work on bone densitometry. Melbourne University awarded him a Doctorate of Science in 1980. During his career he published 100 papers in peer reviewed journals.

Herb died suddenly on July 8th 2020 leaving a solid professional legacy. Recollections of his scientific insight, humour, and ability to get things done will be treasured by his colleagues. His passing leaves an unfillable gap in the hearts of his family and friends who remember him with great affection and respect.

Acknowledgments

This memoir was prepared with much appreciated assistance from Charlotte Bolotin. The incident concerning the "close" guess of the parity was observed and related by Steve Tims.

About the author

Andrew Stuchbery is Head of the Department of Nuclear Physics and Accelerator Applications at the Australian National University, which hosts Australia's Heavy Ion Accelerator Facility. Herb Bolotin was his PhD supervisor; he and Herb worked together on nuclear structure physics and related science for almost two decades.

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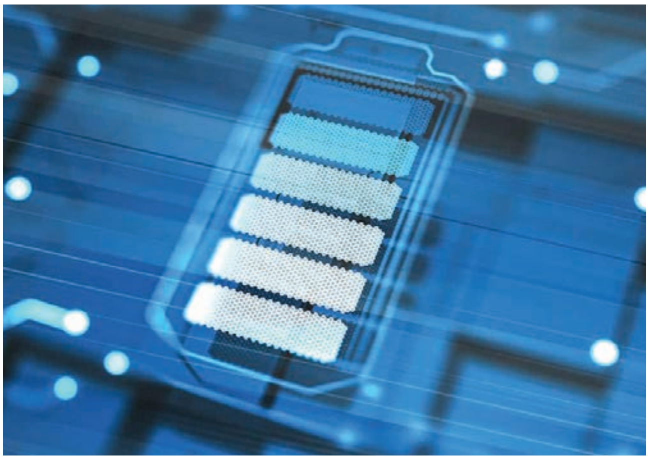
[3] H.H. Bolotin, Bone, 41, 138-154 (2007).

Physics around the world

Lithium-ion batteries recharge in the cold

As temperatures fall below freezing, lithium-ion batteries cannot hold as much charge, so they do not recharge very well. Researchers from China's Jiaotong University say they have now overcome this problem by replacing the traditional graphite anode in these devices with a "bumpy" carbon-based material. The new structure maintains its rechargeable storage capacity down to -20°C, allowing it to be used in cold environments such as those found at high altitudes, in aerospace applications, and for deep-sea exploration, as well as in other electric vehicles that need to work in extreme conditions.



(Courtesy: iStock/MF3d)

Lithium-ion batteries are widely employed in applications ranging from mobile phones to electric vehicles. These devices have a high capacity and high energy density, which means they can store a lot of charge very quickly. During charging, lithium ions move from the cathode to the anode though an electrolyte, which is usually made from a lithium salt dissolved in a liquid organic solvent. At temperatures close to zero degrees Celsius, however, the anodes in these devices can fail to transfer any charge – a phenomenon known as severe capacity degradation.

Modified anode surface structure

Researchers recently discovered that the flat orientation of graphite in the lithium-ion battery anode is responsible for decreasing the battery's energy storage capacity at cold temperatures. In the new work, a team of researchers led by Wang Xi of Jiaotong University's School of Physical Science and Engineering and Jiannian Yao from the Beijing National Laboratory for Molecular Sciences therefore chose to modify the surface structure of this anode in an attempt to improve the energy transfer process in the electrode.

To make their new "bumpy" material, Wang, Yao and colleagues began by heating a cobalt-containing zeolite material, called ZIF-67, at high temperatures. This creates a surface made of 12-sided carbon nanospheres that has a positive curvature, like a bowl. The material has a reversible capacity – a measure of a battery's capacity after many cycles – of 624 mAh/g at -20°C, which is equivalent to 85.9% of its room-temperature energy capacity. Even at -35°C, the reversible capacity was still retained at 160 mAh/g after 200 cycles.

Extending the range of applications for Li-ion batteries

The researchers' calculations revealed that the newly bumpy surface, in effect, wakes up the sluggish behaviour of the Li-ion anode at low temperature thanks to the local accumulation of charges that occupy non-coplanar sp2 hybridized orbitals. These accumulated charges facilitate the charge-transfer process.

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

Wallpaper made of moth wings is an excellent absorber of sound

When moth wings are used to coat hard, artificial surfaces, they can significantly reduce the reflection of incoming ultrasound, researchers in the UK have shown. Without making any modifications to the wings' scale structures, Marc Holderied and colleagues at the University of Bristol showed how the natural metamaterial performs remarkably well as natural soundproofing.

Conventional soundproofing materials tend to be porous, and to be effective they must be thicker than about 10% of the wavelength of the sound they are blocking. Metamaterials made of specially designed structures can be thinner than 1% of the wavelength they absorb, but these tend to operate over a very narrow band of frequencies. While broadband metamaterials have been created, they tend to be much thicker.

To create thinner broadband sound absorbers, some researchers are looking to the wings of moths for inspiration. Bats hunt moths using echolocation, so some moth species have developed a remarkable ability to absorb the high-frequency sound waves bats

Stealthy flier: the Antheraea pernyi moth is very good at absorbing ultrasound. (Courtesy: University of Bristol)

produce. The insects do this using microscopic scales that decorate both sides of their wings.

Range of sizes

These scales come in a broad range of sizes – each with a characteristic resonant frequency. This allows the wings to absorb sound across a wide range of frequencies, making them far more effective than conventional sound-absorbing materials. Previous studies have shown how moth wings absorb sound waves as the insects travel through the air. In their study, Holderied's team looked at how the wings absorb sound when attached to an aluminium disk.

Typically, such a hard, manmade surface will reflect most incoming sound. In contrast, the researchers observed that the moth-wing coating reduced this reflection by up to 87% at the lowest frequencies they tested. The ultrasound used by the team had wavelengths some 50 times longer than the thickness of the wings.

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

Magnetic fields can turn medical waste into high-value products

Alternating magnetic fields can be used to rapidly convert medical waste, such as plastic syringes, into hydrogen-rich gases and high-quality graphite, scientists in China have found. This catalytic technique is more environmentally friendly and less energy intensive than other waste management strategies, the researchers claim. It might also help us dispose of other types of medical waste such as masks and protective clothing.

The coronavirus pandemic produced mountains of medical waste. According to the World Health Organization (WHO), between March 2020 and November 2021, the UN shipped 87,000 tonnes of personal protective equipment (PPE), like masks and

Waste disposal: A process based on alternating magnetic fields could help process the mountains of medical waste produced during the coronavirus pandemic. (Courtesy: iStock/Snezhana Kudryavtseva)

gowns, to countries around the world. But this is only the tip of the iceberg, as it does not cover items purchased outside the UN initiative by governments and members of the public. More than 140 million test kits have also been shipped and the more than eight billion vaccine doses administered globally have produced 144 000 tonnes of waste products, such as syringes, needles and sharps bins.

In the rush to secure PPE and administer vaccines, less attention was paid to waste disposal. But that plastic and biohazardous medical waste is threatening human and environmental health, according to a recent WHO report. Now researchers in China claim to have developed a new catalytic technique that rapidly decomposes disposable syringe plastic, which they say could help.

While it is quick and simple, it can produce large quantities of carbon dioxide and other toxic gases, and the only useful by-product is heat. Plastic in medical waste is rich in hydrogen and recently researchers have developed a two-stage technique that uses high-temperature pyrolysis followed by catalytic cracking to turn it into hydrogen-rich gases such as hydrogen, ethanol and methane. But, according to Xifeng Zhu from the University of Science and Technology of China and his colleagues, this process is very energy intensive.

To address the challenge of efficiently converting medical waste into hydrogen-rich gases, Zhu turned to magnetic hyperthermia. Magnetic hyperthermia generates localized intense heat by subjecting magnetic nanoparticles to a high-frequency alternating magnetic field. So far, this technique has been primarily used within medicine to heat and destroy cancer cells.

The researchers created a catalyst that would respond to a magnetic field by joining ten bent disposable syringe needles together in a chain-like loop. They then added crushed disposable syringes, which were mainly made from polypropylene, and a heavy fraction of bio-oil as an initiator.

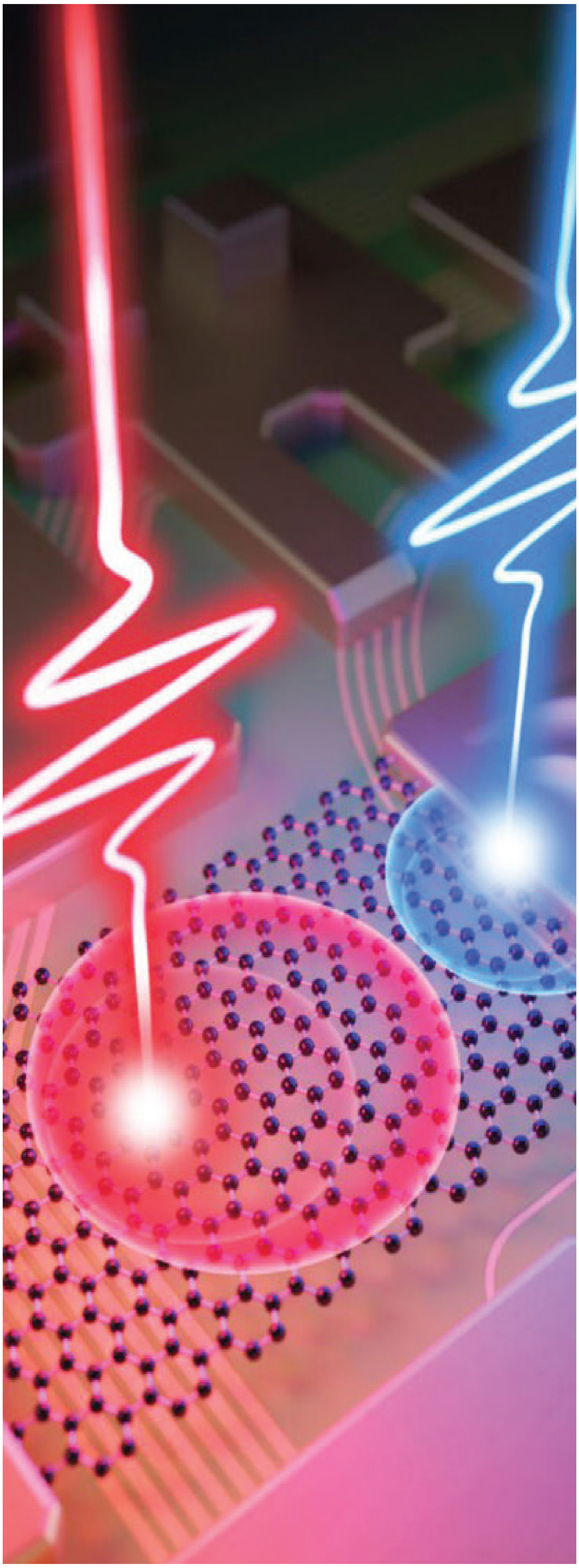
When the team subjected this mix to a high-frequency alternating magnetic field they found that the chain-shaped needles heated up. This heated the bio-oil, which then heated the rest of the system. As the temperature increased, the bio-oil and the plastic syringes decomposed, generating hydrogen, methane and other gases.

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

Logic gate breaks speed record

The first logic gate to operate at femtosecond timescales could help usher in an era of information processing at petahertz frequencies – a million times faster than today's gigahertz-scale computers. The new gate, developed by researchers at the University of Rochester in the US and the Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU) in Germany, is an application of lightwave electronics – essentially, shuffling electrons around with light fields – and harnesses both real and virtual charge carriers.

In lightwave electronics, scientists use laser light to guide the motion of electrons in matter, then exploit this control to create electronic circuit elements. "Since



Towards ultrafast logic gates (Courtesy: University of Rochester illustration / Michael Osadciw)

light oscillates so fast (roughly a few hundred million times per second), using light could speed up electronics by a factor of roughly 10 000 as compared to computer chips," says Tobias Boolakee, a laser physicist in Peter Hommelhoff's group at the FAU and the first author of a study in Nature on the new gate. "With our present work, we have been able propose the idea for a first light field-driven logic gate (the fundamental building block for any computer architecture) and also demonstrate its working principle experimentally."

In the work, Boolakee and colleagues prepared tiny graphene-based wires connected to two gold electrodes and illuminated them with a laser pulse lasting a few tens of femtoseconds (10-15 s). This laser pulse excites, or sets in motion, the electrons in graphene and causes them to propagate in a particular direction – so generating a net electrical current.

Virtual and real charge carriers

Researchers at the FAU and Rochester have been working on lightwave electronics for the past decade, and the latest work takes advantage of their recent discovery that exciting the gold-graphene junction excites two different kinds of electronic charge carriers: virtual and real. The virtual carriers are only set in a net directional motion while the laser pulse is on, the researchers explain, and as such are transient. The contribution of the virtual carriers to the net current must therefore be measured during light excitation.

The researchers performed this measurement by probing a net polarization induced by the virtual carriers in the gold electrodes attached to the graphene. The real charge carriers, for their part, continue propagating in the preferred direction even after the laser pulse is turned off, so their contribution to the net current can be measured after light excitation has ended.

According to the researchers, the results of the measurement were "striking": by changing the shape of the laser pulse, they found they could generate currents in which only the real or only the virtual charge carriers play a role.

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

PRODUCT NEWS

Coherent Scientific

Low kV EBSD is Now Within Reach

Introducing the ClarityTM Super - the first commercially available Electron Backscatter Diffraction (EBSD) Detector with unparalleled performance at beam currents as low as 3kV. This direct detection system is ideal for beam-sensitive perovskite, ceramic, or semiconductor materials that are difficult to analyse using conventional EBSD systems.

As an extension to Clarity Plus, this revolutionary series utilises single-electron detection to provide the high-fidelity EBSD pattern quality and unparalleled sensitivity that you expect to move your research forward.

- Using low beam currents reveals never-before-seen structures, prevents damage, charging and draft
- Delivers unparalleled spatial resolution at low beam energies
- Resolves fine details in low signal-to-noise conditions for clearer patterns

For further information please contact Jeshua Graham

sCMOS for EUV and Soft X-Ray Applications

Marana-X is Andor's ground breaking sCMOS platform tailored to EUV and soft X-Ray applications. Hand crafted to deliver market leading performance and versatility Marana-X reads out a 4.2 Megapixel high resolution array in less than 50 milliseconds while maintaining very low read noise. The Marana-X is available in two models, a large area 11µm 4.2 megapixel format and a 6.5µm 4.2 megapixel format.

High Resolution - 4.2 megapixel

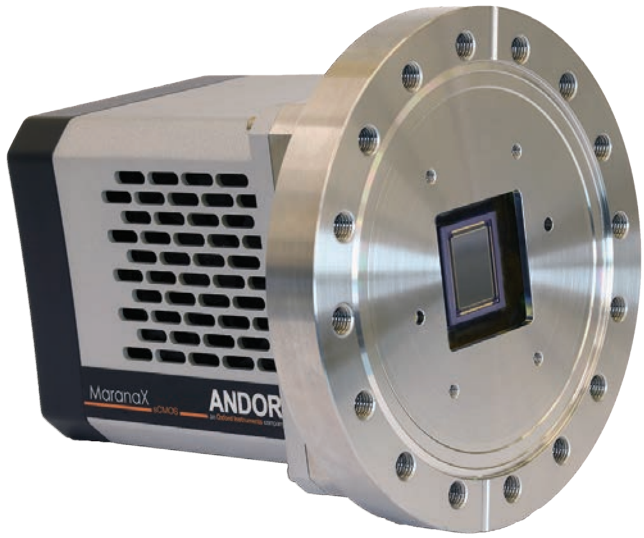
High Sensitivity - Up to 99% QE

Fast Speeds - Up to 74 fps

High Dynamic Range - Up to 16-bit

EMP Resistant - CoaXPress data interface

For further information please contact Michael Buckett.



pulseCheck NX autocorrelator

The pulseCheck NX is a leap forward in the evolution of a product line, which has been market leading and trusted for more than 25 years. The new autocorrelator design implements an unprecedented level of integration, including software, electronics, mechanics and optics (Fig 1 page 34).

Low-noise analogue electronics and fast digital components allow for excellent signal to noise ratios and seamless data transfer. A mature optical design and meticulously tested components ensure reliable and industry leading performance down to 200 nm.

The pulseCheck NX provides plug & play capability via USB and Ethernet connections.

For further information please contact Dr Paul Wardill.

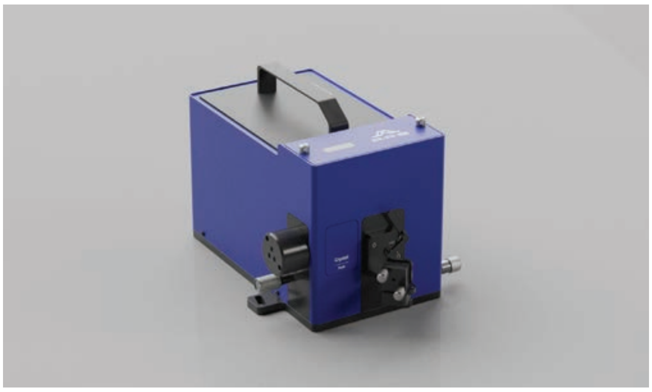


Figure 1: pulseCheck NX autocorrelator

Coherent Monaco 1300 for Three-Photon Microscopy

Three-photon microscopy is an increasingly popular imaging modality as it offers the potential for much deeper imaging compared to two-photon or single-photon fluorescence microscopy.

However, the specific wavelength, pulse energy and repetition rate required for optimal three-photon imaging have until now dictated the use of rather complex and cumbersome "multi-box" laser systems.

Coherent has solved this problem with the introduction of the new Monaco 1300, a 1300nm light source developed specially for three-photon microscopy.

For further information please contact Dr Paul Wardill.

Coherent Scientific Pty Ltd
sales@coherent.com.au
www.coherent.com.au

Lastek Pty Ltd

IS Instruments ODIN: Compact Deep UV Raman Spectrometer

Lastek represents ODIN from IS Instruments: a compact deep UV Raman spectrometer. Deep UV Raman spectroscopy operates in the ultraviolet range of the spectrum, between 200 and 280nm and offers the ability to detect, identify and quantify substances at much lower concentrations than is possible with near-UV, visible, or infrared (IR) methods.

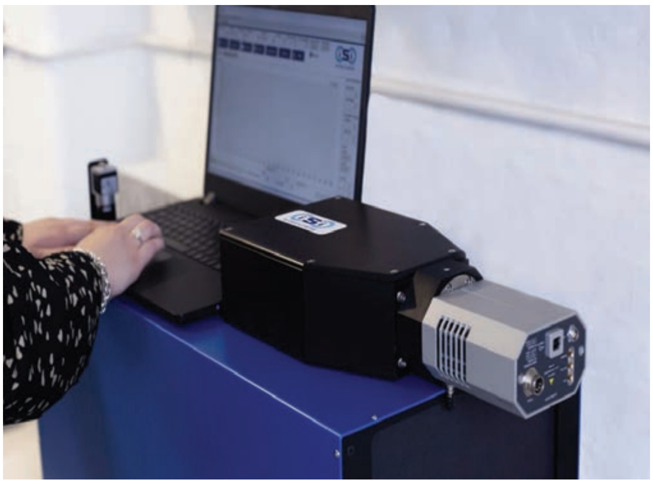
ODIN is a compact, ancillary-free instrument capable of unprecedented Raman characterisation of complex biological materials.

Key features/benefits:

- Size - ODIN is an order of magnitude smaller: it fits on a desk.
- Price - it's significantly more affordable than other instruments
- Diode laser - no water cooling or gas purge required.
- Maximises throughput while limiting power density at the target

Applications include:

- Biopharmaceutical
- Biomedical
- Security/Defence
- Explosives detection
- Identification of hazardous materials
- Process Manufacturing



Tucsen Dhyana 400BSI V3 BSI sCMOS camera designed lighter and with less power to integrate and fit in small spaces

The Tucsen Dhyana 400BSI V3 is undoubtedly the best camera available featuring the Gpixel Gsense2020BSI sensor, being designed to easily integrate and fit in small spaces, using less power, giving results you can rely on that you or your customers can make the correct decisions.

Features:

- 95%@600nm Peak QE
- 6.5μm x 6.5μm Pixel Size
- 2048 x 2048 Resolution
- 100fps@CL, 40fps@USB3.0
- CameraLink & USB3.0

Lighter and Less Power

The weight only 995g and the power consumption only 45W makes Dhyana 400BSI V3 the lightest and the least power in its class and so easy to integrate and fit in small spaces.

100fps@4MP

Dhyana 400BSI V3 has been upgraded from 74fps to 100fps, reaching the limit readout speed of 4MP resolution at CameraLink mode. You may also get higher frame rate support by ROI function.

Rolling Shutter Control Mode

Dhyana 400BSI V3 has developed a new technology named as Rolling Shutter Control Mode, which allows users to add defined line time delays or slit heights to synchronize scanning modes in applications such as Light-Sheet Microscopy.

Specification:

- Model:Dhyana 400BSI V3
- Sensor Type:BSI sCMOS
- Sensor Model:GSENSE2020BSI
- Peak QE:95%@600nm
- Color/Mono:Mono
- Array Diagonal :18.8mm
- Effective Area:13.3mm x 13.3mm
- Resolution:2048(H) x 2048(V)

Raman Spectroscopy in Australia

Lastek offers one of the most comprehensive selection of Raman spectrometers and other instrumentation for Raman spectroscopy in Australia, backed by the most experienced team of laser spectroscopists and optical engineers. Read more...

Our range of products includes spectrometers from leading manufacturers Ocean Insight, Nanobase, Zolix, Nanonics and IS Instruments, together with instruments, sources and optics for Raman spectroscopy from Thorlabs, Laser Quantum, and more. With 5 PhDs on staff, and extensive capabilities in optical design and custom systems, Lastek is the ideal partner for your Raman spectroscopy application. Please explore our website for full details of systems which we offer. We also invite you to contact Dr Zhen Fang-Gong at Lastek to discuss in detail your Raman spectroscopy project.

For further information, please contact
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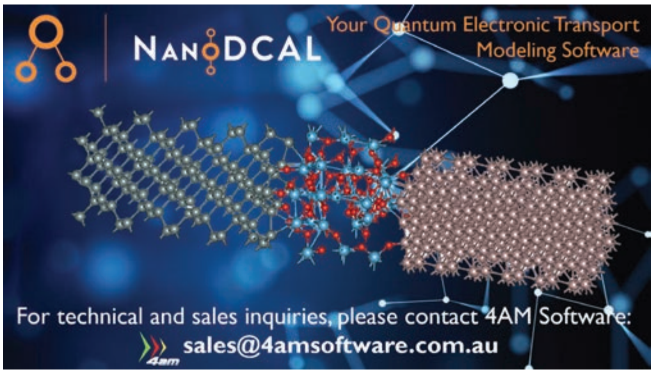
NANOACADEMIC Technologies

NanoDCAL

NanoDCAL offers reliable and powerful quantum transport simulation features to model nanostructures or nanodevices. It is an atomic orbital implementation of NEGF-DFT. It computes the Hamiltonian of materials and devices from first principles (i.e., without external parameters) using density functional theory (DFT) and simulates quantum transport phenomena within the Keldysh non-equilibrium Green function formalism (NEGF). NanoDCAL includes a large suite of methods for calculating important transport properties of your materials. NanoDCAL was used in hundreds of peer-reviewed papers in domains as varied as molecular electronics, nanotubes, topological insulators, batteries, magnetic tunnel junctions, metal grain boundaries (crystallites) and more: all of them can be found referenced on our website, under Technical Insights menu. It has demonstrated efficiency, so why not test it? Unleash the full power and functionality of NanoDCAL by obtaining a parallel license and use it at its full potential.



Main NanoDCAL features are the following:

- Written in MATLAB and C
- Focus on molecular and nanoscale electronics (small to large scale 1k+ atom systems)
- Spintronics (collinear / non-collinear / spin-orbit coupling)
- Semiconductor nanoelectronics (I-V curve)
- Several features such as total energy, force, scattering states and phonons calculations are part of NanoDCAL suite
- Study molecules, crystals, one-probe and two-probe systems
- Force, stress, structure optimization
- Electron-phonon coupling
- Atomic orbital basis optimizer
- Photocurrent
- Thermal transport coefficients

We offer licenses for single users and research groups and some options such as the HPC (parallel version) and advanced training and support services.

A free trial version is available for testing. Create your free user account today and start using our advanced atomistic tool, today!

RESCU

RESCU – Real space Electronic Structure CalcUlator – is a powerful MATLAB-based density functional theory (DFT) and DFPT (perturbation theory) solver. It can predict the electronic structure and derived properties of bulk materials, material surfaces and molecules. RESCU calculates the ground-state density using a basis of numerical atomic orbitals, plane-waves or real space grids, or a combination of them. Written with the objective of solving systems comprising up to a few tens of thousands of atoms, RESCU is carefully parallelized and exploits libraries such as MPI, ScaLAPACK and CUBLAS. It includes many state-of-the-art analysis tools such as density of states (DOS), projected density of states (PDOS), local density of states (LDOS, PLDOS), finite-displacement phonon and band structure. It has some unique features that most if not all other commercial codes on the market do not have.

Main RESCU features are the following:

- Written in MATLAB and C
- Focus on large scale systems (up to 20k atoms)

- DFPT implementation (e.g., dielectric tensor, dynamical matrix)
- Optical properties (e.g., dielectric permittivity, refractive index)
- Raman tools (e.g., tensor, spectrum, intensities)
- Advanced functional treatment such as DFT + EXX (hybrid) and DFT + U (Hubbard)
- Common analysis tools like DOS, PDOS, LDOS, PLDOS, band structure, band-unfolding, charge analysis
- Non-linear optical susceptibility
- Spintronics (collinear / non-collinear / SOC)
- Phonon tools (finite-difference-based)
- Large scale CFSI solver

We offer licenses for single users and research groups and some options such as the HPC (parallel version) and advanced training and support services.

A free trial version is available for testing. Create your free user account today and start using our advanced atomistic tool, today!

QTCAD

Nanoacademic Technologies Inc.'s QTCAD newly released software is unique on the market and enables to study arbitrary gated quantum dot configurations in semiconductors including for example advanced III-V alloys such as GaN and AlN (Nitride) materials, but all semiconductors can be studied. QTCAD is the only commercially available computer-aided design software with all the features needed to model spin qubits in gated quantum dot devices, namely, device electrostatics at cryogenic temperature, single-particle Schrödinger solvers for electrons and holes within k.p theory, and quantum-mechanical many-body solvers accounting for Coulomb interactions within the gated quantum dots. QTCAD simulations have recently been used in the interpretation of experiments with industrially fabricated gated quantum dot devices such as FD SOI architectures.

Main QTCAD features are the following:

- An electrostatics tool that solves the confining potential of quantum dots in semiconductor nanostructures;
- A valley-splitting calculation tool;
- An exact diagonalization tool for rigorous treatment of few-electron systems;

- A master equation solver for quantum transport calculations in the sequential tunneling regime enabling treatment of Coulomb blockade and predicting charge stability diagrams;
- Our electric-dipole spin resonance module interfaces with QuTiP for time-dependent simulations of quantum control;
- Works at cryogenic (sub-K) temperatures in many practical designs of solid-state spin qubits, which is a notoriously difficult problem to solve with available TCAD software;
- Arbitrary 1D, 2D and 3D device geometries are defined via Gmsh using our adaptive meshing technique to avoid time-consuming manual mesh refinements. Simulations are launched using our user-friendly Python API.

Many more features are in the works to extend the reach of QTCAD over quantum technologies and more physics phenomena. We offer licenses for single users and research groups and optional advanced training and support services.

QTCAD is now commercially available for academic users, a Professional version will launch soon (companies: please contact us for more information on info@nanoacademic.com).

A free trial version is available for testing. Create your free user account today and start using our advanced quantum modeling tool, today!

Contact Us

Visit us for more technical descriptions on our website www.nanoacademic.com and linked documentation: https://docs.nanoacademic.com/.

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