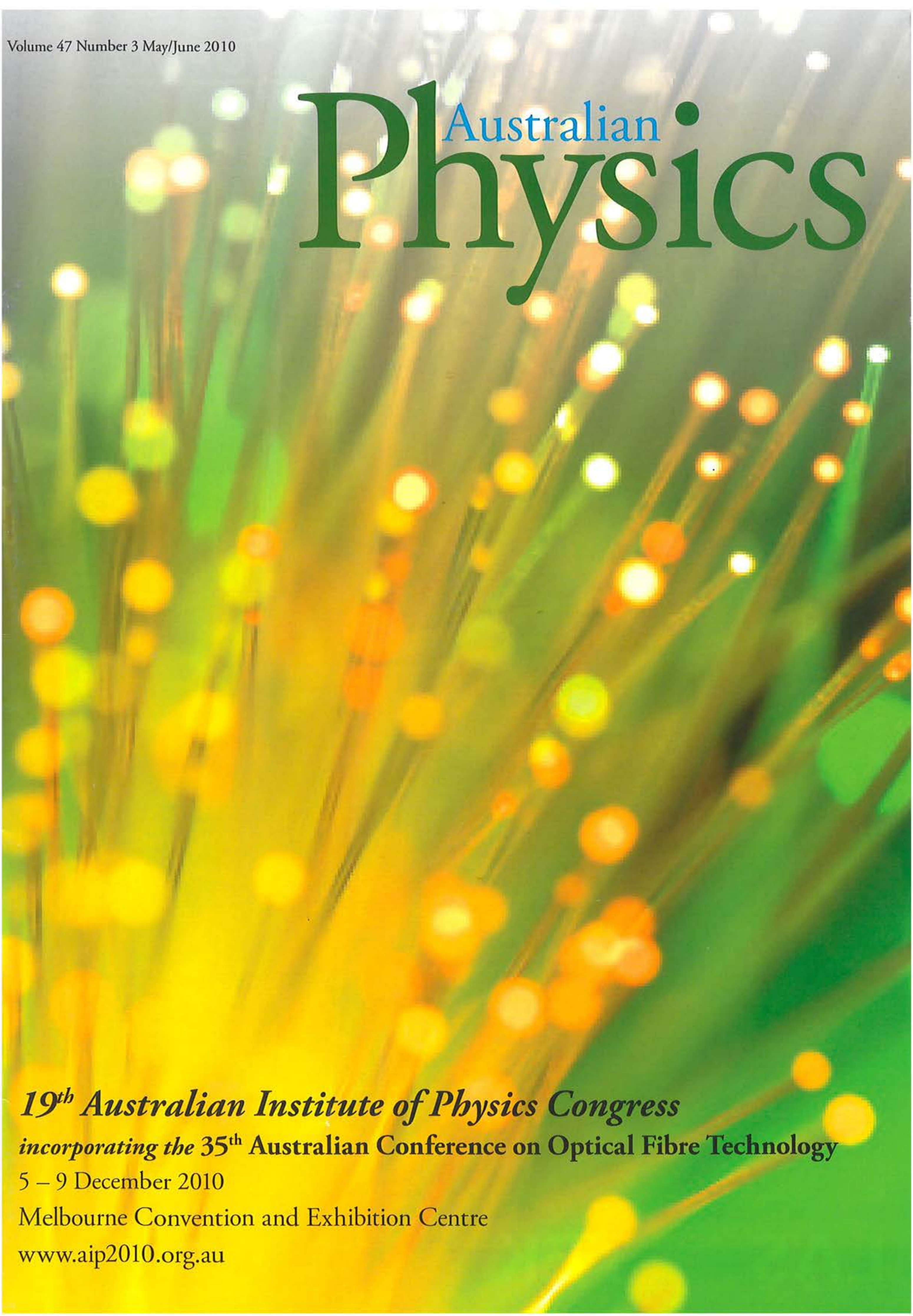
Volume 47 Number 3 May/June 2010

Australian Physics



19th Australian Institute of Physics Congress

***incorporating the* 35th Australian Conference on Optical Fibre Technology**

5 – 9 December 2010

Melbourne Convention and Exhibition Centre

www.aip2010.org.au

A Publication of the Australian Institute of Physics

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

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Articles for submission to Australian Physics should be sent in electronicaly. Word or rich text format are preferred. Images should not be embedded in the document, but should be sent as high resolution attachments in eps, tiff or jpg. Authors should also send a short bio and a recent photo. The Editor reserves the right to edit articles based on space requirements and editorial content. Contributions should be sent to the Editor-in-Chief.

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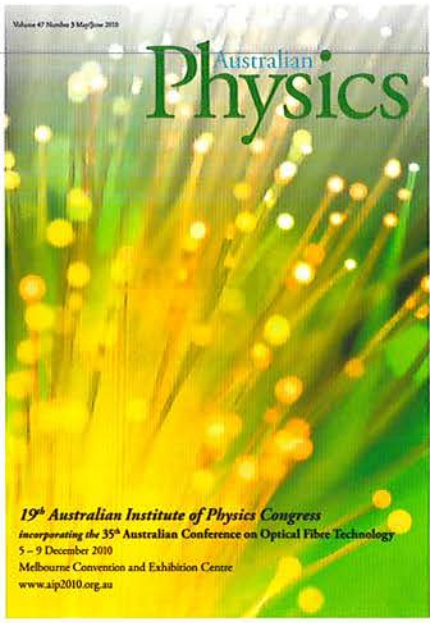
Published 6 times a year.

Pub. No. PP 224960 / 00008
ISSN 1837-5375

Australian Physics



Cover

Our cover is an invitation from the Australian Institute of Physics and the Victorian branch to the 19th Australian Institute of Physics Congress to be held at the new Melbourne Convention and Exhibition Centre from 5th – 9th December 2010. Additionally, the Australian Optical Society and Engineers Australia highlights the co-location of the 35th Australian Conference on Optical Fibre Technology (ACOFT).

The AIP/ACOFT 2010 Congress will be the biggest and most diverse scientific meeting of the Australian physics calendar. The AIP Congress attracts many of Australia's finest physicists plus a number of prominent overseas attendees. It provides a forum for discussions within specialist physics topic areas and opportunities for physicists from academia, government, industry and the commercial sector to keep up to date in areas outside their core interests.

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Printing
Pinnacle Print Group
288 Dudas Street, Thornbury VIC 3071
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Editorial

You and the new Australian Physics

I am absolutely convinced about the importance of ***Australian Physics***. It is the Flagship publication of our Australian Institute of Physics, and a unique space for discussions relevant to students and physicists, particularly those working in Australia. Conspicuously lacking, though, is a pipeline of articles for our magazine. But if physicists are known as great publishers, why such a small interest in contributing for our magazine? I believe there are at least two reasons: The magazine is indexed, but not being a scientific publication it might be perceived as an interesting place to publish, but with little contributing to impact factors, citations, etc. The number of physicists working in Australia is not as large as across Europe or North America.

We are also trying to improve the quality of the magazine. From this issue, all articles are being proof-read by authors. We are adopting standards for publication while being flexible with the submission process to encourage and facilitate contributions.

It is absolutely impossible to improve this publication without your feedback. I received very good comments from a large number of colleagues: some shared their previous experience with editorial work, as regular readers and authors. The best way for us to have a better magazine is to provide this constant feedback. Thank you all for writing to me and sharing your opinion. Further comments are very welcome. Some changes in this issue include the use of a larger font, a lighter use of red lines, and as I said the proofreading process. You should expect the ***Australian Physics*** to change over coming issues from your feedback.

In this issue we have some interesting histories for you. A fascinating article about the neutron interferometry written by Tony Klein with an illustration kindly provided by Gerry Lants, an Australian cartoonist working for the Herald and Weekly Times, Melbourne. After 35 years since its first implementation, neutron interferometry has produced some fascinating demonstrations of quantum mechanics in action; has allowed the testing of a number interesting quantum mechanical propositions and has allowed the precise measurement of physical quantities of vital importance in condensed matter physics. The entire story starts a few pages from here.

Another interesting article is the history of the development of wireless communication by Peter Pockley. The research carried out more than 20 years ago in radio astronomy has led to a transformation in how we use the Internet. John O'Sullivan explains to Peter Pockley how he and his research team invented the technology behind Wi-Fi.

The third article of this issue discusses the marvels of quantum science and the challenges to engineer the quantum world.

In *Book Reviews* we have selected four interesting books for you. This is the opportunity to thank our Books Reviews Editor Dr John Roldsworth for his contribution for the ***Australian Physics***. He is leaving us and our President has already distributed an invitation for those interested in playing this role.

We also have in this issue an article from David Blair which is a touching retrospective of inspiring John de Laeter's career.

At the end we provide a list of good conferences for your information. At this time we feature a letter from the 2010 AIP Congress Ann Roberts and Andrew Peele.

Many readers contacted the authors of articles from the previous issues. The article on superconductivity by John Macfarlane was edited further from what I wish and a small, but interesting session on geophysical applications of superconductivy was left behind (now on page 88 of this issue). John has made his original manuscript available. He has also kindly agreed on writing a article on that topic for our special issue on Superconductivity. Yes, we will feature a special issue to celebrate the 100-year anniversary of the discovery of Superconductivity.

Finally, I would like to express my gratitude to all colleagues at AIP. I have received incredible support from our Editor-in-Chief, editorial board, associate editors, Prof Neville H. Fletcher for his feedback on style and Don Price from CSIRO for a list of samplings that attracted his attention recently.

I hope you will enjoy!

Paulo de Souza

President's column

Role of Physics

In July 2010 the last of three reports on matters associated with the unauthorised release of emails from the Climate Research Unit (CRU) at the University of East Anglia (UEA) was released. The report, the Independent Climate Change E-mails Review, was prepared by a review team set up by UEA in consultation with the Royal Society and chaired by Sir Muir Russell (*1*). It followed a report of an international panel set up by UEA and chaired by Lord Oxburgh (*2*), and prior to that a report from the House of Commons Science and Technology Committee (*3*). The reports cover all relevant issues, albeit with varying emphases, and their conclusions are consistent. Taken together they find no evidence that would invalidate the scientific output of the CRU, nor the integrity of the scientists involved. They do however criticise the lack of openness with which research was conducted, and the unwillingness to facilitate access by others to the raw data. It is worth exploring these issues a little further.

In order to put this criticism in context it is necessary to realise that the relevant work by CRU related to deducing global temperature trends based on land station temperature measurements from many different sites and temperature reconstructions from tree ring analyses. CRU did not acquire the raw data themselves: they obtained it from others but were responsible for processing it, and combining data from various sources, in order to compile a global land temperature record. According to the CRU website, they "developed a number of data sets widely used in climate research, including the global temperature record used to monitor the state of the climate system, as well as statistical software packages and climate models".

While the Oxburgh report found no evidence of deliberate scientific malpractice, they identified a consistent pattern of failing to display the proper degree of openness, which had a potential to put at risk the reputation of UAE and the credibility of UK climate science. It noted that a particular figure supplied for a 1999 World Meteorological Organisation (WMO) report was misleading in that it did not explain clearly how data was manipulated (although it noted that the particular procedure itself was not a problem), and that the uncertainties involved may not have been properly taken unto account. Furthermore it found that it was regrettable that work that relied heavily on statistical methods had not been carried out in collaboration with professional statisticians.

The Russell report found that the rigour and honesty of the CRU scientist was not in doubt, that there was no reason to cast doubt on the extent to which their work could be trusted and relied upon, and their behaviour did not prejudice the balance of advice given to policy makers or to the International Panel on Climate Change (IPCC). It did however find that CRU's response to reasonable requests for information were unhelpful and defensive, and that the procedures used for splicing data were not made sufficiently plain. This report also made some more general observations. It called for all sides of the climate debate to adopt the conventional scientific method of checking and seeking to falsify conclusion or offering alternative hypotheses for peer review and publication. It confirmed that peer review is an essential part of this process but cautioned that it should not be overrated as a guarantee for correctness.

The House of Commons report specifically recommended that as standard practice raw data and details of methodologies, including computer codes, should be available to others. While acknowledging that this was a level of detail not traditionally included in published papers, it suggested that the internet now provided the obvious vehicle for achieving this.

In summary these reports found that there was no evidence for scientific malpractice, but there should have been more openness. They provide confirmation of the robustness of standard scientific practice, which is self-correcting provided practitioners explain clearly what they have done so that others are in a position to assess the work and, in principle, reproduce it. It is unfortunate that most of those who heard of the incident via the mass media, often sensationalised due to the fact that it occurred just before the Copenhagen Summit, are unlikely to read these reports, or even become aware of their findings. Thus many will maintain a view of scientific practice that is informed by the media reports only. It is a characteristic of modern media that controversy and conflict often wins out over reasoned discourse and balance is seen as balance of strongly held opinion, where the weight of evidence for views presented is not tested.

1. Independent Climate Change E-mails Review, July 2010, http://www.cce-review.org/

2. Report of the International Panel set up by the University of East Anglia to examine the research of the Climatic Research Unit, April 2010, http://www.uea.ac.uk/mac/comm/media/press/CRUstatements/SAP

3. The disclosure of climate data from the Climatic Research Unit at the University of East Anglia, March 2010, http://www.publications.parliament.uk/pa/cm/cmsctech.htm

Brian James

Launching the wireless revolution

The technology behind the Wi-Fi

by Peter Pockley

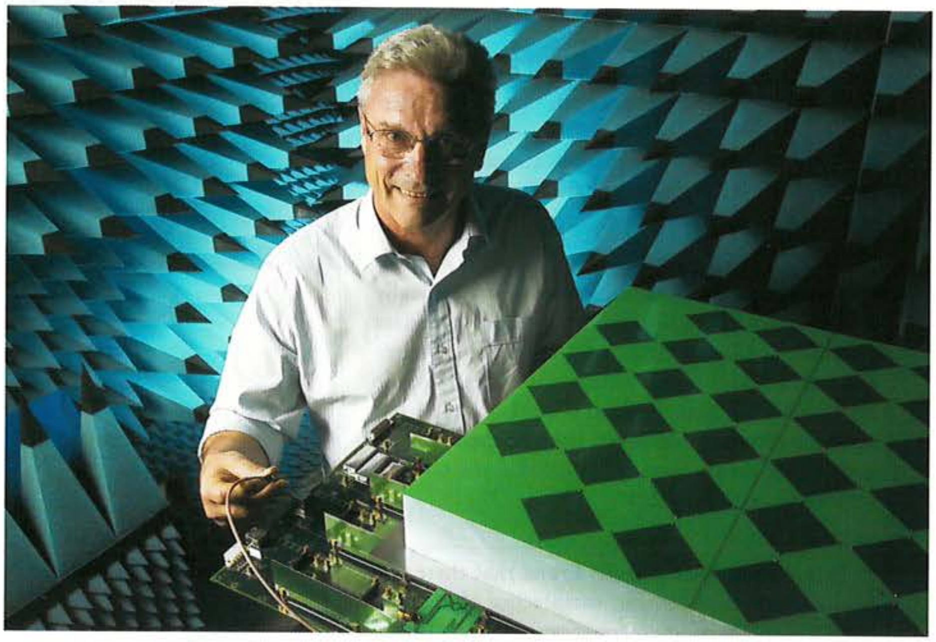


Fig. 1. Dr John O'Sullivan with the revolutionary detector-receiver array he has developed in CSIRO for the ASKAP telescope. Credit: Chris Walsh, Patrick Jones Photo Studio.

John O'Sullivan has been a quiet achiever in the Australian science community. He comes across as naturally modest, never claiming to have been a prolific publisher of scientific papers or to have contributed anything special to the field of radio astronomy in which he has worked all his life. But some would think otherwise. His record, after all, not only contains many significant research papers but also 14 patents from applying his research to commercial developments.

Fig. 2. The young Dr John O'Sullivan working in 1985 on designing the first version of the FFT chip. Photo: Courtesy Dr O'Sullivan

Undoubtedly his most important patent was the one he earned in 1992 when he was working at Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO). The patent was based on taking a technique that was used to combine signals from radio telescopes and applying it to how computers send and receive signals. It has not only earned CSIRO millions in royalties, but also garnered O'Sullivan and his research team credit for pioneering the so called Wi-Fi revolution. Wi-Fi is a wireless local area network (WLAN) standard that allows devices with computational ability to communicate with each other by sending and receiving radio waves at frequencies of about 3 GHz. This method also allows "Wi-Fi enabled" devices to connect to the Internet by a computer sending radio signals to a wireless modem, which is then connected to a telephone cable. So successful has Wi-Fi become that some 800 million laptops, printers, mobile phones and other devices around the world used this ubiquitous invention to connect to the Internet last year – a figure that is set to rise to four billion by 2013. O'Sullivan admits to being taken back by the impact of his invention. "At first, we only saw basically business applications such as networking and portable computing as growth areas," he says. "But what we see now far exceeds our expectations. We are utterly surprised by the scale." Yet O'Sullivan is virtually unknown, even within the physics community, despite the huge impact of his discovery. While Tim Berners-Lee is almost a household name for having pioneered the World Wide Web, O'Sullivan – whose invention lets us to connect to the Internet wherever we are – is unknown to most.

One of the main reasons for this lack of high profile is a legal battle that has so far lasted for eight years between CSIRO and a number of companies that also claim to have had a hand in creating Wi-Fi. But as the legal challenges began to be dropped last year, O'Sullivan is finally beginning to gain public recognition after being awarded the A$300,000 Australian Prime Minister's science prize from Kevin Rudd in October 2009. Since then, O'Sullivan's team has also won the CSIRO chairman's medal for inventing Wi-Fi and the Clunies Ross prize from the Australian Academy of Technological Science and Engineering in late May.

"What we see now far exceeds our expectations. We are utterly surprised by the scale."

Stimulating experiences

With degrees in physics and electrical engineering from the University of Sydney, O'Sullivan completed his PhD in astronomy while working at the university's radio telescope comprising 64 steerable dishes at Fleurs, near Sydney. In 1974 he moved to the Netherlands, where he designed a unique receiver for the groundbreaking Westerbork Synthesis Radio Telescope, which studies the structure of distant galaxies and has 14 steerable dishes operating at 1420 MHz spread along a 3 km east–west line. This type of interferometer is known as "aperture synthesis" and uses a receiver that mixes signals from a collection of telescopes to produce a single image with the same resolution as an instrument the size of the entire collection. His new receiver boosted the sensitivity of the telescope by a factor of five.

While O'Sullivan was in the Netherlands, he also pioneered techniques to analyse weak signals and to sharpen them at optical and radio frequencies. Working with Ron Ekers and Peter Shaver, both then at the University of Groningen, O'Sullivan looked for radio pulses that might emanate from mini black

holes, as predicted by Cambridge university theorist Stephen Hawking. By using the Dwingeloo 25 m telescope near Westerveld in the Netherlands, O'Sullivan devised a high-speed detector to pick up the signals disturbed by charged particles in the interstellar medium – regions of space containing gas and dust. This work led researchers to consider the use of fast Fourier transform (FFT) processors to increase sensitivity (Nature **276** 590).

In 1983 Bob Frater, O'Sullivan's lecturer at the University of Sydney, persuaded him to come back to Australia to establish a signal-processing group at CSIRO. O'Sullivan was charged with finding commercial applications, for example in medical imaging, from research done by CSIRO's radioastronomy group. However, he opted instead for an adventurous path of developing microprocessing chips that could operate FFTs on radio signals sent and received within the lab. He therefore attempted to find a viable way of "cutting" the wires between computers that greatly limited their mobility, and his invention was the starting point for the wireless Internet age (see box).

Fig. 5. Dr John O'Sullivan (right) with engineer Brett Preisig testing the prototype phased array antenna feed atop the test bed antenna (behind) for the Australian SKA Pathfinder project at Parkes. Photo: Bearcage Productions

Communicating without wires, Wireless technology for computers, had existed before O'Sullivan designed his new method of communicating via radio waves. Motorola had a WLAN device dubbed ALTAIR that oper-

Fig. 3. CSIRO's wireless LAN patent inventors with their successful testbed apparatus; from left, Graham Daniels, John O'Sullivan, Terry Percival, John Deane, Diethelm Ostry. Photo: Courtesy Dr O'Sullivan

ated at 18 GHz. However, it could only run at about 5 Mbits per second and was very costly and large to implement. The Motorola system used "directional antennas", which, in effect, created a single transmission path between the sender and the receiver. The problem with these "point-to-point" radio transmissions is that the receiver has to stand exactly in line with the sender for the technique to work.

In the confined space of an office or home, however, radio transmissions inevitably result in multiple reflections that bounce off hard surfaces such as walls many times and mean that the receiver picks up lots of different signals. O'Sullivan's team solved this problem by designing a way of taking these multiple signals and converting them into a single signal so that the receiver and transmitter could be positioned anywhere in the room and did not have to be directly in front of each other (see box). O'Sullivan's system was first documented in a patent entitled "A Wireless LAN", which was applied for in 1992 at the Australian Patent Office and contained details of a wireless transceiver and a method of transmitting data. "The best choice we ever made was deciding that the group should aim high in going for a transmission speed of 100 MB per second, which would support video transmission and require a new solution," says O'Sullivan. "One overseas group had dismissed this idea as 'off the planet'." O'Sullivan's Australian patent was followed in 1996 by a crucial global endorsement with a US patent awarded to the CSIRO team, which included O'Sullivan, Graham Daniels, John Deane, Diethelm Ostry and Terry Percival. The US patent was important as it opened the way to the largest potential market.

Business acumen

O'Sullivan's reputation as a pioneer in the Wi-Fi revolution of the early 1990s caught the eye of Rupert Murdoch's multinational

News Corporation, which recruited him as director of technology in 1995 to improve the delivery of pay TV in Australia, Japan, the UK and the US. While at News Corporation, O'Sullivan consulted, part-time, for Radiata Communications, a company spin-off from Macquarie University, in Sydney, and CSIRO to develop a WLAN chip under a non-exclusive licence from CSIRO.

Some of the original inventors and subsequent research collaborators had formed Radiata as shareholders. Radiata had its headquarters in the US, where its chief executive, Don McLennan, lived, but with R&D and an operating base remaining in Sydney. The company quickly became a shining example for Australian scientists of how to commercialize basic research. On leaving News Corporation in 2000, O'Sullivan took a full-time role in Radiata, initially as chief technical officer and later as vice-president for systems engineering. Later that year, the company demonstrated the first working chip for WLAN, which produced the then phenomenal transmission speed of 54 MB per second, and performed according to the definition of a global standard by the International Institute of Radio and Electronic Engineers – dubbed 802.11a – for carrying out WLAN computer communication in the 2.4 and 5 GHz frequency bands. Yet the discovery of Wi-Fi has been blighted by legal battles and controversy.

At a computer-networking convention in Atlanta, US, in September 2000, Radiata, which had licensed the CSIRO technology and patent, staged the first commercial demonstration of a wireless link with the transmission of a short sequence from the movie Ronin from one computer to another using 802.11a Wi-Fi connectivity. "After the first public demonstration, the big companies were all eyes," says O'Sullivan. The large US networking company Cisco Systems had been following Radiata's progress and in 2000 quickly pounced with a takeover bid of about A$600m. Radiata became part of the wireless-business unit of Cisco and O'Sullivan managed the integrated circuit team from 2001 to 2004.

He and the founding shareholders were paid with Cisco options or shares, while Cisco acquired CSIRO's licence to apply the technology in the Radiata chip design. CSIRO has pursued legal action in the US over a number of years to licence its WLAN technology to firms that use it in their products. In April 2009, 14 contesting companies, including Dell, Intel and Microsoft, settled out of court for about A$250m in total. O'Sullivan would not comment about the case and negotiations are still continuing with other companies. However, early this year CSIRO was reportedly planning to sue three top US mobilephone operators – Verizon Wireless, AT&T and T-Mobile – over claims that they had been selling devices that infringe its patents, with possibly payments to CSIRO totalling $1bn. O'Sullivan is now project scientist in receiver design for Australia's bid for the Square Kilometre Array (SKA) – a gigantic multinational project currently being assessed for siting in either South Africa or Australia. He is involved with testing the first antennas of ASKAP – a prototype of SKA – that will make it the world's most powerful survey radio telescope when it comes online later this year. But it is likely to be his Wi-Fi invention that will leave a lasting mark on Australian science. CSIRO is now using the money from royalties for an A$150m national endowment fund for science and industry to support research in all disciplines. O'Sullivan has also pledged to give part of his prize money from the Australian science award to support the fund.

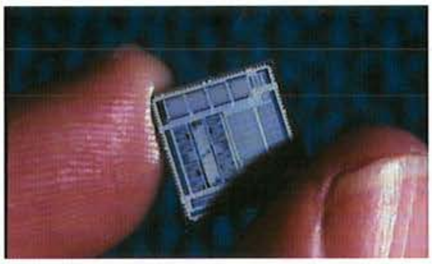
Fig. 6. Dr John O'Sullivan at presentation ceremony of the Prime Minister's 2009 Prize for Science. Photo: Peter Pockley.

Acknowledgements:

Reproduced with kind permission from Physics World (UK). The author, Dr Peter Pockley, is a science writer and broadcaster, based in Sydney. In May this year he was granted the rarely awarded Medal of the Australian Academy of Science for his role as the pioneering science correspondent in the Australian media and, more broadly, "for advancing the cause of science and technology in Australia".

From Fourier Signals to Wireless Network

Working in the Netherlands in the late 1970s, astronomer John O'Sullivan was attempting to detect radio waves from particles emitted by black holes that were predicted by the Cambridge university physicist Stephen Hawking. After spending years searching for a good signal, he found that the signals were too distorted to be used, so employed a mathematical construct called a Fourier transform (FT) to remove the noise and improve the data. FTs work by separating a wave, such as a radio signal, into many component parts or tones. A similar reverse process can be used so that individual tones can be made into a single signal. The fast Fourier transform (FFT) is an algorithm that decreases the computing time of the FT and its inverse, thus reducing the number of processing steps. Even though O'Sullivan designed a computer chip to perform the FFT calculations, he failed to detect the radio waves from black holes. In 1990 O'Sullivan and colleagues applied their knowledge to create a computer network that sent and received radio waves, thus cutting out the need for wires. O'Sullivan's team found that the radio waves bounced off any surfaces in the surrounding area, which caused echoes in the signal and made efficient data transfer impossible. The team realized, however, that it was possible to send the information over many different frequencies and recombine the signal with the help of an FFT at the receiver. Interference from echoes was eliminated and the invention enabled computers to send and receive radio signals with data transfers rates of better than 10 MB per second. ***Michael Banks***



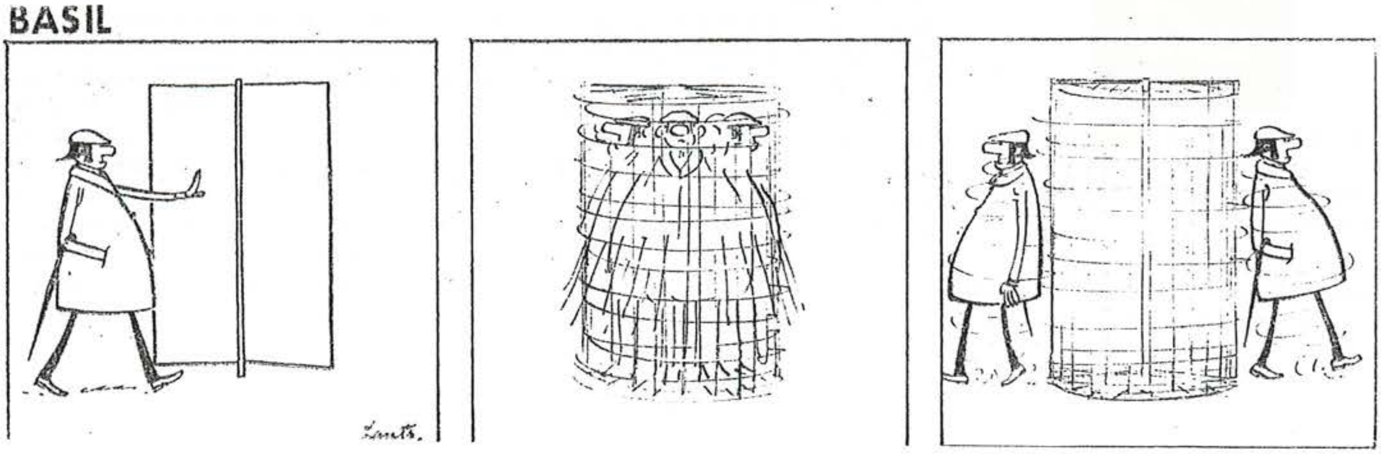
This first version of the FFT chip (designed by CSIRO with support from Austek) contained 90,000 transistors. The subsequent Austek + CSIRO version had double that number. Photo: Courtesy Dr O'Sullivan.

"...early this year CSIRO was reportedly planning to sue three top US mobilephone operators over claims that they had been selling devices that infringe its patents, with possibily payments to CSIRO totaling $1bn."

Neutron Interferometry

a Tale of three Continents

by Tony Klein



In the 35 years since its first implementation, neutron interferometry has produced some fascinating demonstrations of quantum mechanics in action; has allowed the testing of a number interesting quantum mechanical propositions and has allowed the precise measurement of physical quantities of vital importance in condensed matter physics. This was one of the conclusions that emerged from the Vienna Symposium on the Foundations of Modern Physics held in June this year. Organised by Anton Zeilinger, ably assisted by Markus Aspelmeyer and the staff of the Institute of Quantum Optics and Quantum Information (IQOQI) this Symposium, the second in the series, also served as a Festschrift for Helmut Rauch and Danny Greenberger, noted experimental and theoretical luminaries in the field. In particular, it was Helmut Rauch who, together with Wolfgang Treimer and Ulrich Bonse, was first to demonstrate the Single Crystal Neutron Interferometer in 1974 (*1*). Closely analogous to a Mach-Zehnder Interferometer in classical optics, these wonderful devices are carved out of a monolithic piece of highly perfect single crystal of silicon, of the kind used in the semiconductor electronics industry. A photograph and a schematic are shown in Figure 1.

Three parallel slabs of silicon, connected by a base, contain perfectly aligned planes of atoms, which, by virtue of Bragg diffraction, coherently split a beam of monochromatic neutrons, whose wavelengths are comparable in magnitude to the lattice spacing of the silicon crystal. Furthermore, the silicon is almost completely transparent to neutrons – so that absorption is essentially negligible. Thus, the first slab acts as a beam splitter, with a transmitted and a diffracted beam emerging from it. Both these beams continue to the second slab at which Bragg diffraction occurs once again. Ignoring the transmitted beams (which escape from the system), the two diffracted beams continue on their way to the third, equidistant slab, where they recombine in a way similar to the first beam splitter.

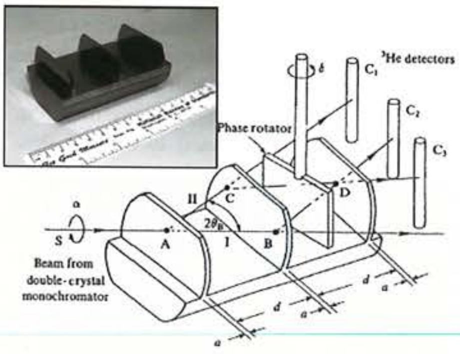


Fig. 1. Schematic of a perfect crystal neutron interferometer. The output beams are counted in detectors C1 and C2 while C3 serves as a monitor of the total flux. The inset is an actual photograph of themonolithic silicon crystal device.

Although we have ignored the complex interplay of the beams inside the crystal slabs, which can only be calculated by using the dynamical theory of diffraction, by some miracle the three slabs of the silicon crystal act like the half-silvered mirrors in the optical interferometer. Several centimetres separate the internal beams, but there is only one neutron inside the device at any given time. However, in the usual quantum mechanical prescription, it is impossible to tell which of the paths the neutron has taken – it travels along both paths at the one time!

The relative phases of the beams are influenced by inserting material slabs of different thicknesses inside the interferometer – in practice by tilting the one slab of material so that the beams traverse different thicknesses – and thus the interaction of the neutrons with the nuclei of the materials can be measured to a very high degree of precision. In effect this is a measurement of the refractive index of thematerial for neutrons that, in turn, depends on the scattering lengths of its constituent nuclei – important data in neutron diffraction crystallography.

Rauch's and other research groups have performed a large number of such measurements over the years, using powerful neutron beams at the High Flux Reactor of the Institut Laue – Langevin (ILL) in Grenoble.

But no sooner was such a neutron interferometer constructed in Europe, a very similar one was produced in the USA, and the way was open for a large number of beautiful and fundamental experiments, each of them testing some aspect of quantum mechanics and exploring the fundamentally analogous behaviour of particles and waves. In fact, for doing macroscopic wave-optical experiments with neutrons. Shortly after the demonstration of the first neutron interferometer by Rauch and his colleagues at the small research reactor of the Atominstitut in Vienna, Sam Werner and his colleagues at the Ford Motor Company Research Labs in Michigan (and later at Purdue University), designed and built similar devices and performed spectacular experiments with them. The competition was on! Instead of just inserting material objects inside the interferometers one of the first experiments of the American group famously demonstrated the effect of the earth's gravity on the neutron beams inside the interferometer.

In what has become known as the COW

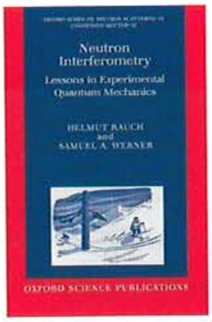


Fig. 2. Cover of the monograph by Rauch and Werner (Oxford University Press, 2000). It contains details of 40 experiments and 1000 references.

experiment (*2*) (after Colella, Overhauser and Werner) the interferometer was tilted about a horizontal axis parallel to the incoming beam.

"In 35 years since its first implementation, neutron interferometry has produced some fascinating demonstrations of quantum mechanics in action; has allowed the testing of a number of interesting quantum mechanical propositions and has allowed the precise measurement of physical quantities of vital imporance in condensed matter physics."

In this way, the two diffracted beams inside the interferometer become separated by a vertical distance and thus experience different gravitational potentials, by traveling at different heights above the earth's surface. The resultant phase differences become apparent in an interferogram plotted as a function of beam height difference. The measurement may be expressed using a formula that simultaneously involves Planck's constant h, and the gravitational constant g, the first macroscopic manifestation of a quantum-mechanical effect due to gravity. The next spectacular experiment was also one in which a field, instead of a material object, was to act on the neutrons – this time a magnetic field. But by then a third research group had entered the competition – this time from Australia. My late colleague Geoffrey Opat from the University of Melbourne and I, came across a paper by Aharonov and Susskind (*3*) proposing a gedanken experiment with electrons to demonstrate the peculiar behaviour of fermions, *i.e.*, particles with half-integral spin, when rotated by 360° about any axis: they do not return to their original state, like any macroscopic object, but develop a minus sign in their wave function. Up until then considered as merely a mathematical artifact, this minus sign is in fact crucial in explaining the Pauli exclusion principle that is responsible for the stability of ordinary matter. (The connection is explained in a side panel.) To perform the rotation required in an experimental verification, a magnetic field is made to act on the intrinsic magnetic moment of the fermions, causing them to precess. The phase shift caused by the rotation can be made apparent in an interference situation; the minus sign, *i.e.* the 180° phase shift caused by an odd number of 360° rotations, will lead to destructive interference.

We immediately realised that neutrons would be needed to demonstrate the effect – electrons would be swept aside by the Lorentz force - and so did Rauch's group in Vienna and so did Sam Werner, who by this time had moved to the University of Missouri. As a matter of fact, a paper by Herbert Bernstein (*4*) published almost simultaneously with the Aharonov – Susskind paper, explicitly suggested neutron interferometry to demonstrate the effect, several years before the first crystal interferometer was built.

That was the case for the Melbourne group too – we planned an interference experiment with neutrons in 1974 before we heard about the crystal interferometer, which in any case, we didn't have. Our experiment was based on interference by division of the wavefront, analogous to Young's two-slit experiment in classical optics. We proposed to diffract slow neutrons around a magnetic domain wall in a thin crystalline foil of iron alloy with the right properties. Having the right thickness would allow the neutrons to precess in the internal magnetic field inside the iron foil, so that the total precession angle would give an integral number of times 360°. For an odd number of revolutions, destructive interference should occur between the parts of the neutron wavefunction that traversed oppositely directed magnetic fields.

ILL accepted this proposal in 1974 and we published it in 1975 (*5*). But by the time I arrived to perform the experiment, in September 1975, I found to my consternation that the corresponding experiment had already been done – by the Rauch group (using an electromagnet inside a crystal interferometer), as well as by the Werner group (using a permanent magnet). Their results, verifying this strange property of fermions, were published simultaneously in Physics Letters (*6*) and Physical Review Letters (*7*), in October 1975. We lost the competition for priority, but we went ahead and did our version of the experiment anyway – because it used a significantly different method.

Our results, which also verified the theoretical prediction, ended up being published in 1976 (*8*). However, what had started out as a competition between the three research groups on three continents turned into something completely different. Catalysed by the first conference on neutron interferometry, held at ILL in 1980, co-operative experiments followed for the next 20-odd years, with various combinations of participants.

Fig. 3. (Left to Right) The European (Rauch), American (Werner) and Australian (Klein) Collaborators.

The European and Australian groups co-operated on a series of neutron-optical experiments in 1979, including interferometry, and

"As quantum-mechanical playgrounds, neutron interferometers have thrown much light on the arcane mysteries of particles-acting-like-waves, over and above their role in precise measurements and experimental tests."

demonstrated the effect of the motion of materials inside a neutron interferometer – analogous to the famous experiments of Fizeau in classical optics (*9*).

Meanwhile, the American group demonstrated the effect of the earth's rotation on the phase shift of neutrons – analogous to the experiments of Michelson and Gale in classical optics and only about 2% of the magnitude of their earlier gravity experiment. There followed a series of experimental collaborations between the Australians and the Americans in the 1980's further exploring the effects of the motion of matter on the phase shift of neutrons, demonstrating a null effect that depends on the velocity independence of the neutron-nucleus interactions (*10*).

Later collaborations, in the 1990s explored a number of topological effects, analogous to the famous Aharonov - Bohm propositions in electrodynamics. The analogous effects for neutral particles, named after Aharonov and Casher, showed thatmoving neutrons can feel the effects of an electric field, in spite of being electrically neutral, because of their magnetic moment (*11*). Furthermore, it became possible to demonstrate an analog of the so-called scalar Aharonov - Bohm effect that had hitherto not been observed with electrons (*12*). The role of neutron interferometry in observing such geometrical and topological phases was reviewed in two recent conferences celebrating Yakir Aharonov and Michael Berry on the occasion of the 25th and 50th anniversaries of their discoveries (*13*). An unintended but felicitous outcome of the Australian – American collaboration was that my research student Bill Hamilton ended up marrying Sam Werner's research student Mohana Yethiraj; both of them are now gainfully employed at the Australian research reactor OPAL after having been research scientists at Los Alamos and Oak Ridge National Laboratories for many years.

The culmination of the European – American collaboration was the publication of a very interesting textbook on neutron interferometry (Figure 2), in which the experiments that I described are fully elaborated along with many others and which, incidentally, contains all the references to the original publications. As quantum-mechanical playgrounds, neutron interferometers have thrown much light on the arcane mysteries of particles-acting-like-waves, over and above their role in precise measurements and experimental tests. The main protagonists (Figure 3), now happily retired, are proud of their achievements!

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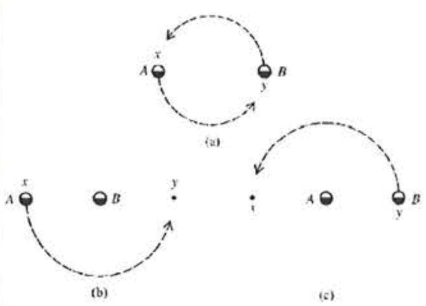
Acknowledgements:

The author acknowledges Gerry Lants, Australian cartoonist © Herald and Weekly Times, Melbourne.

The Author:

Professor Emeritus Tony Klein held a Personal Chair in Physics in the University of Melbourne until his retirement in 1998. He served as President of the Australian Institute of Physics (1990 – 91); Head of the School of Physics (1986 –95); was elected a Fellow of the Australian Academy of Science in 1994 and was appointed a Member of the Order of Australia in 1999. He has published extensively in experimental physics, particularly about neutron optics.

The Pauli Principle Explained



Feynman in an article entitled "The reason for antiparticles" (14) showing that the exchange of two particles (a) corresponds to each being rotated by 180° (b) and (c) i.e. 360° of relative rotation. If a fermion (e.g., electron, proton or neutron) develops a minus sign in the wavefunction when rotated by 360° then two identical particles in the same spin state cannot occupy the same position in space because they would interfere destructively if exchanged. Hence the Pauli Exclusion Principle! This "hand-waving" argument was put on a more solid mathematical footing by Michael Berry and Jonathan Robbins (15).

Junctionless transitor makes its debut

http://physicsworld.com/cws/article/news/41881

Researchers in Ireland have succeeded in making the first junctionless transistor ever. The device, which resembles a structure first proposed in 1925 but not realized until now, has nearly "ideal" electrical properties, according to the team. It could potentially operate faster and use less power than any conventional transistor on the market today.

Jean-Pierre Colinge and colleagues at the Tyndall National Institute of University College Cork have dispensed with the very idea of a junction and instead have turned to a concept first proposed in 1925 by Austrian-Hungarian physicist Julius Edgar Lilienfield. Patented under the title "Device for controlling electric current", it is a simple resistor and contains a gate that controls the density of electrons and holes, and thus current flow.

The team's version of the device consists of a silicon nanowire in which current flow is perfectly controlled by a silicon gate that is separated from the nanowire by a thin insulating layer. The structure itself is very simple, looking a bit like a telephone cable that is fixed to a surface by a plastic clip. Crucially, there is no need to alter the doping over very short distances. Instead, the entire silicon nanowire is heavily n-doped, making it an excellent conductor. However, the gate is p-doped and its presence has the effect of depleting the number of electrons in the region of the nanowire under the gate.

Hydrocarbon superconductor is a first

http://physicsworld.com/cws/article/news/41898

Ryoji Mitsuhashi and colleagues at Okayama University in Japan have made the first superconducting hydrocarbon material by adding potassium atoms to picene ($C_{22}H_{14}$).

http://www.nature.com/nature/journal/v464/n7285/full/nature08859.html.

The material becomes superconducting at temperatures below 18 K – something that has surprised physicists and could provide clues about the physical origins of superconductivity.

Two years ago Kosmas Prassides at the University of Durham, Matt Rosseinsky at Liverpool University and colleagues showed that a solid made of carbon-60 molecules (buckyballs) and caesium was a superconductor below 38K. These materials differed from other carbon-based superconductors because the superconductivity involves carbon's p-electrons – opening up a new avenue for systematic studies.

Like the carbon-60 crystals, superconductivity in picene is believed to be related to p-electrons. But according to Prassides, the superconductivity comes as a surprise because picene molecules arrange themselves in 2D planes much like graphite. This is unlike carbon-60 crystals, which have a cubic structure that matches the cubic symmetry of the p-electron orbitals. This means that a carbon-60 crystal has several different electron energy states with the same energy – and this "degeneracy" is expected to play a role in its superconductivity.

Picene does not have this cubic symmetry and therefore should not have the required p-orbital degeneracy. It turns out, however, that by pure coincidence, picene has two p-electron states with the same energy. Prassides believes that this "accidental degeneracy" could be related to the superconductivity.

See also the summary at:

http://www.nature.com/nature/journal/v464/n7285/full/464039a.html.

The first sound 'lasers'

http://physicsworld.com/cws/article/news/41857

Two independent research groups have unveiled the first phonon "lasers" – devices that emit coherent sound waves in much the same ways as lasers emit coherent light waves. Sometimes called "sasers", one of the devices emits sound at about 400 GHz while the other operates in the megahertz range.

Such very high frequency sound could be used to probe the interiors of tiny objects – and the ability to create laser-like beams of sound could lead to new imaging applications. Indeed, the differences between the two devices suggest that sasers could be made to operate over a wide range of frequencies.

Just as lasers rely on stimulated emission of photons, sasers require stimulated emission of phonons. While there is no reason why stimulated emission shouldn't work for phonons, physicists had struggled to find materials in which stimulated emission – rather than random spontaneous emission – is the dominant decay process. Now, two independent groups have come up with two very different solutions to this problem.

At the University of Nottingham in the UK, Tony Kent and colleagues have made a saser that operates at about 440 GHz. Their device comprises alternating layers of the semiconductor gallium arsenide (GaAs) and the insulator aluminium arsenide (AlAs). Meanwhile at the California Institute of Technology (CalTech), Ivan Grudinin and colleagues use two microwave resonators – each about 6 μm in diameter and made of silica – to create the phonon-producing transition for their saser. The resonators are separated by a gap of about 1 μm, which is small enough for the devices to be coupled via light waves to form a two-state quantum system.

The devices are described in Phys. Rev. Lett. 104 083901 and Phys. Rev. Lett. 104 085501.

See also:

http://www.nature.com/nature/journal/v464/n7285/full/464011b.html).

Both answers-correct in centrury-old optics dilemma

http://physicsworld.com/cws/article/news/41873

For 100 years scientists have been struggling to reconcile two different formulations describing the momentum of light travelling through a transparent medium. One, put forward by German mathematician Hermann Minkowski in 1908, stipulates that light's momentum increases when it enters a medium, while the other, advanced a year later by the German physicist Max Abraham, instead says that the momentum of light decreases. Now, Stephen Barnett of the University of Strathclyde in the UK has concluded that both formulations are in fact correct, with the difference essentially boiling down to whether one considers the wave or particle nature of light (Phys. Rev. Lett. **104** 070401).

Both formulations have received experimental support, particularly that of Minkowski. For example, in 2005 Wolfgang Ketterle and colleagues at the Massachusetts Institute of Technology reported evidence in favour of Minkowski by transferring momentum from laser beams to matter waves that had been formed from a few million atoms cooled to just above absolute zero. However, in 2008 a group led by Weilong She of Zhongshan University in China passed a laser beam through a tiny filament of silica and found that the filament recoiled as the light exited, indicating, in accordance with Abraham, that the light gained momentum as it left the material.

According to Barnett, however, both formulations are correct. Simply put, Abraham described the momentum of light as a particle whereas Minkowski described the momentum of light as a wave. However, it is thought that the debate isn't really over. The question is: when is the particle momentum relevant and when is the wave momentum relevant?

Samplings

Quantum dots for highly efficient solar cells

http://physicsworld.com/cws/article/news/43000

The efficiency of solar cells could be increased to more than 60% from the current limit of just 30% according to new work by scientists in Minneapolis and Texas. The new work involves capturing the higher-energy sunlight that is normally lost as heat in conventional devices using semiconductor nanocrystals, or quantum dots.

The maximum efficiency of conventional solar cells made from silicon-based semiconductors is limited by theory to around 31% – and the best performing affordable commercial devices are less than 20% efficient. This is because in typical devices, photons with energies above the semiconductor's bandgap generate "hot" charge carriers (electrons and holes) that quickly cool to the band edges in a matter of just picoseconds, releasing phonons (vibrations of the crystal lattice, or heat). If the energy of these hot electrons could be captured before it is converted into wasted heat, solar-to-electric power-conversion efficiencies could be increased to as high as 66%, say scientists.

The first step towards doing this has already been demonstrated – by research done in 2008 by Philippe Guyot-Sionnest's group at the University of Chicago who showed that hot electrons can be slowed down in semiconductor nanocrystals. Now, Xiaoyang Zhu at the University of Texas at Austin and colleagues at the University of Minnesota, Minneapolis, have discovered a second important step: how to capture the electrons before their energy is lost.

The team found that the electrons can be transferred from photo-excited lead selenide (PbSe) crystals to an adjacent electronic conductor made of titanium dioxide. The researchers demonstrated the effects in quantum dots made of PbSe but the method could work just as well for quantum dots made from other materials.

The full paper is published in Science: http://www.sciencemag.org/cgi/content/full/328/5985/1543 Physicists at Harvard University have gained important insights into the process of crystallization by studying how tiny plastic balls spontaneously form clusters. They found that highly symmetric clusters are created much less often than those with lower symmetry, which could shed light on how clusters of atoms or molecules form just before a liquid solidifies into a crystalline solid.

Observation of the role of entropy during crystallization is difficult because clusters of atoms are too small and appear and vanish much too quickly to be seen. But by using clusters of much larger particles, which can be observed in real-time with an optical microscope, Vinothan Manoharan and colleagues at Harvard University in the US have been able to gain new insight into the role of entropy in the "nucleation" process.

See also http://www.sciencemag.org/cgi/content/full/327/5965/535

Plank captures the Universe coming to life

http://physicsworld.com/cws/article/news/43110

The European Space Agency's Planck mission has released its first full-sky map. The image shows the cosmic microwave background (CMB) in higher resolution than ever before and it may help cosmologists to develop a much clearer picture of the early universe.

The Planck mission was launched in May 2009 with the main goal of mapping the CMB, the primordial radiation created about 375,000 years after the Big Bang. Slight variations in the temperature of the CMB are believed to reflect fluctuations in the early universe from which large structures such as galaxies would later evolve.

In 2003 the first full-sky survey of the CMB was produced by NASA's Wilkinson Microwave Anisotropy Probe (WMAP). In addition to temperature, WMAP also measured the degree of polarization of the ancient microwave photons – providing more information about the early universe. The Planck mission is expected to surpass WMAP by detecting a so-far unobserved type of polarization known as "B-modes", which are believed to date back to the period of inflation and are determined by the density of primordial gravitational waves.

The image released today is generated from six months' worth of data, and ESA is expected to release the first scientific analysis of the image within two years.

Polymer analysis using nanopore-based single-molecule mass spectrometry

http://www.pnas.org/content/107/27/12080.full

Nanometer-scale pores have demonstrated potential for the electrical detection, quantification, and characterization of molecules for biomedical applications and the chemical analysis of polymers. Despite extensive research in the nanopore sensing field, there is a paucity of theoretical models that incorporate the interactions between chemicals (*i.e.*, solute, solvent, analyte, and nanopore). A group from NIST (Gaithersburg, Maryland) has developed a model that simultaneously describes both the current blockade depth and residence times caused by individual poly(ethylene glycol) (PEG) molecules in a single α-hemolysin ion channel. Modeling polymer-cation binding leads to a description of two significant effects: a reduction in the mobile cation concentration inside the pore and an increase in the affinity between the polymer and the pore. The results suggest that rational, physical models for the analysis of analyte-nanopore interactions will develop the full potential of nanopore-based sensing for chemical and biological applications.

When does photoemission begin?

http://www.sciencemag.org/cgi/content/full/328/5986/1658

The process of photoemission was one of the effects that led to the formulation of quantum mechanics. If an atom or surface absorbs sufficient energy from incoming light, it can transfer that energy to an electron, which is then emitted. Theories of photoemission mainly focus on energetics—the temporal or dynamic aspects are ignored—but complex electron interactions occur that will create a slight delay between light absorption and electron emission. This time delay has been poorly understood for a fundamental reason: we cannot "see" an atom absorbing a photon. At best, we can follow subsequent emission events and use them to establish a "time zero" when the light was absorbed. A practical challenge has been that the time delay is extremely short, and only recently have direct experiments been feasible with the advent of lasers that emit pulses on the attosecond (as, 10^{-18} s) time scale. Now, Schultze and co-workers present measurements of time delays of ~20 attoseconds between 2s and 2p photoemission in a Ne atom, generated by the same ultrashort light pulse. This finding not only allows further studies of the timing of photoemission but also provides a new way to investigate electron interactions in atoms.

The complex dynamics of atomic photoemission has a simple origin—the emission of a negatively charged electron changes the neutral atom into a positive ion. The energy levels of the remaining electrons are different in the positive ion, and as the electrons adjust to their new energy levels, they release energy that is transferred to the outgoing electron. The time needed for this transfer is the origin of the small time delays.

See also this Science Perspective article:
http://www.sciencemag.org/cgi/content/full/328/5986/1645.
http://www.sciencemag.org/cgi/content/full/327/5967/853

Temporal tomography

http://www.sciencemag.org/cgi/content/full/328/5986/1668

Tomography is a widely used technique for visualizing three-dimensional objects by algorithmic reconstruction from multiple two-dimensional images from distinct vantage points. However, its application has largely been restricted to static imaging. Kwon and Zewail from Caltech have now adapted an ultrafast electron microscope to perform

tomography with subpicosecond resolution. The method relies on systematically varying the tilt angle of the sample with respect to the incoming electron beam, and enabled assembly of a detailed frame-by-frame record of the response of a curled carbon nanotube to sudden heating.

X-ray laser peels and cores atoms

http://www.nature.com/nature/journal/v466/n7302/full/nature09177.html

The world's first X-ray free-electron laser - the Linac Coherent Light Source (LCLS) at SLAC National Accelerator Laboratory in Menlo Park, California - came online last year. It opened a new era for studies at the atomic level, including the prospect of single-shot imaging of complex nano-objects such as biological molecules. The new facility produces ultrashort (femtosecond) pulses of high-intensity X-rays at a wavelength of less than 1.5 nm.

The results of one of the first experiments aimed at understanding how these ultra-intense X-rays interact with matter have just been reported by Young et.al. The experiment examined the electronic response of free neon atoms to such radiation. During a single X-ray pulse, the atoms sequentially ejected all their ten electrons to produce fully stripped neon - 'hollow' atoms that are X-ray transparent. The authors explain the observations and underlying mechanisms of electron stripping using a straightforward model, which bodes well for further studies of interactions of the X-rays with more complex systems.

See also this Nature commentary:

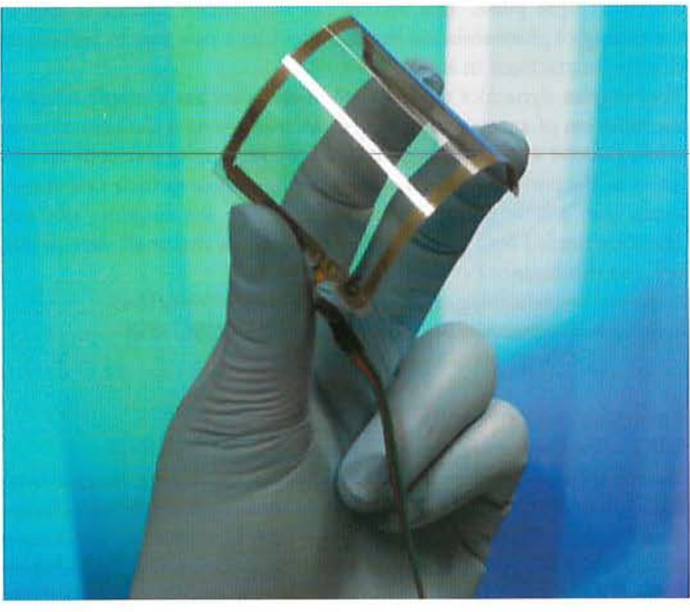
http://www.nature.com/nature/journal/v466/n7302/full/466035a.html

Graphene touch screens

http://www.nature.com/nnano/journal/vaop/ncurrent/full/nnano.2010.132.html

A touch-screen with transparent electrodes made from graphene - single layers of carbon atoms - could be thinner, cheaper and more durable than today's devices that use indium tin oxide. But it has proved hard to manufacture these transparent films efficiently on a large scale.

Now Byung Hee Hong, Jong-Hyun Ahn at Sungkyunkwan University in Suwon, South Korea, and their colleagues have made such films (pictured) using a scalable industrial manufacturing process and incorporated them into a touch screen. They created 30-inch graphene films by depositing carbon atoms onto copper, which is later etched away.



Amide bonds made in reverse

http://www.nature.com/nature/journal/v465/n7301/full/nature09125.html

Amide bonds are ubiquitous as the backbone of natural peptides and proteins, and are also present in many therapeutic small molecules. Conventional laboratory synthesis of the bond relies principally on dehydrative approaches, with the carbon and nitrogen retaining electrophilic and nucleophilic characters, respectively, during carbon–nitrogen bond formation. Now, Johnston and colleagues (Vanderbilt University, USA) describe a new route for amide synthesis involving a reversal of reactant polarity (a process known as umpolung) through the iodonium activation of amines and nitroalkanes. It has a number of advantages over current techniques, including convenience and the availability of a wide variety of starting compounds, and has the potential to develop as an efficient means of enantioselective synthesis of peptides and amide-containing small molecules.

Johnston and colleagues' approach to amide synthesis is operationally straightforward, versatile and exciting. Given access to any basic collection of standard organic compounds, chemists will certainly be able to implement this method quickly. The mechanistically unusual process also opens up new possibilities. See also this Nature commentary:

http://www.nature.com/nature/journal/v465/n7301/full/4651020a.html

Science metrics

http://www.nature.com/news/specials/metrics/index.html

Scientists today are accustomed to having their performance assessed by numerical yardsticks. 'Science metrics' took off with the introduction of Science Citation Index in the 1960s, and many new methods of assessment have been tried since. But are metrics as widely used as those being measured seem to think? A Nature readers' poll and survey of institutions around the world reveals a complicated picture. Many researchers feel that institutions put too much faith in 'suspect' metrics, though many administrators suggest that traditional methods such as personal recommendation generally trump the numerical indicators. Not all metrics tests are the same, however, and if they get better perhaps they should replace the old ways. Richard Van Noorden reports on the plethora of techniques now available, and on the thorny question of what, exactly, they measure. And in an Opinion piece, the opinions of six researchers are canvassed as to how metrics methodology can be improved. Do these metrics work? Are they fair? Are they over-used?

Pulling apart molecular magnetism

http://physicsworld.com/cws/article/news/42924

A single molecule constitutes the ultimate nanometer-scale object through which electronic transport can take place. A research team led by Dan Ralph of Cornell University has now showed how magnetism and quantum many-body phenomena can be tuned by precise mechanical manipulation of single molecules. They investigated the magnetic states of individual spin = 1 molecules placed between two electrodes in a metal break junction. The break junction experiment enables measurement of the electrical conduction through single molecules (Karl Muller and Jan Herrman at CMSE Lindfield carried out such experiments in recent years). By stretching the electrodes, the US researchers explored the resulting symmetry-breaking effects of this mechanical action on the conduction properties through the molecule, focusing on magnetic anisotropy.

The ability to mechanically tune the magnetic anisotropy of individual molecules provides the opportunity to systematically investigate and theoretically compare quantum chemistry models, which will enormously broaden our knowledge of molecular magnetism. Beyond the

fundamental science level, it may play an important role in the use and manipulation of nanoscale magnets for spintronics and quantum information processing applications.

The original paper is published in Science:
http://www.sciencemag.org/cgi/content/full/328/5984/1370
along with a Science Perspective article:
http://www.sciencemag.org/cgi/content/full/328/5984/1362

Building bubbles cascade

http://physicsworld.com/cws/article/news/42898

Researchers in the US have used a high-speed camera to watch the bursting behaviour of bubbles lying on the surface of a glass slide – and found they burst in a cascade that produces increasingly smaller bubbles and eventually jets of liquid. The study, carried out by Jacy Bird and colleagues at Harvard University, could help to improve processes used to make foamy materials. It could also boost our understanding of how ocean bubbles inject aerosols into the atmosphere.

Bird was inspired to do the research after noticing that a ring of small bubbles is produced when a large bubble bursts on a surface. To study the process in more detail, the team covered a glass slide in a film of water plus surfactant and then used a syringe to blow a bubble that is a centimetre or so in diameter. The bubble, which remains on the slide and therefore assumes a hemispherical shape, was pierced at its summit. The researchers then used their high-speed camera to see what happens next.

The bursting was seen to occur in two distinct steps: the formation of concentric doughnut-shaped bubbles when the penetrated rim folds back on itself; and the breakup of these unstable doughnut bubbles into a ring of "daughter" bubbles on the surface. On a liquid surface, the daughter bubbles penetrate the liquid so that they are no longer hemispherical. In this case, their collapse resulted in narrow jets of liquid rising from the surface. A mathematical model that reproduced the folding effect was created. The team repeated its experiment using a number of liquids with different viscosities and surface tensions and with bubbles of different radii: three distinct types of behaviour were observed.

Bird believes that a better understanding of this cascade process could help researchers to fine tune processes for making foams, and that the research could further our understanding of the atmosphere because jets emerging from bubbles on the surface of the oceans are known to be a major source of aerosols. The original paper is in Nature:
http://www.nature.com/nature/journal/v465/n7299/full/nature09069.html

Spotting fake bank note with butterfly colour

http://physicsworld.com/cws/article/news/42861

The animal kingdom often steals the show with its fantastic "structural colours" that can manipulate light in some weird and wonderful ways. One such beauty is Papilio blumei, a butterfly native to Indonesia, whose wings manage to combine green and blue in varying mixes depending on your viewing angle. This particular effect has now been mimicked by a group of researchers in the UK who say that their man-made structural colours could be added to bank notes to help prevent forgery.

The wings of Papilio blumei, while appearing to be dominated by bright green coloured areas, are speckled with cavities that are yellow at the centre, gradually blending into blue at the tips. Light from the centre of the cavity is directly reflected whereas light hitting the edges is initially deflected towards a substructure in the cavity, which consists of alternating layers of cuticle and air. When it finally re-emerges, the light has been partially polarized and comprises a mixture of wavelengths, creating the effect of structural colour.

The mechanism of this colour mixing was detailed in a pair of papers published in 2000 and 2001 co-authored by Pete Vukusic at the University of Exeter. Ten years later Vukusic has teamed up with researchers at the University of Cambridge to recreate the effect in the laboratory. Jeremy Baumberg, one of the researchers based at the University of Cambridge, says that it has taken 10 years to recreate the effect because of the intricate nature of the cavity structure. However, he says that the team's production process could be easily scaled-up to produce large quantities of materials that create these colour-mixing effects.

See the original paper in Nature Nanotechnology:
http://www.nature.com/nnano/journal/vaop/ncurrent/full/nnano.2010.101.html).

Molecularly imprinted polymer nanoparticles: A plastic antibody

http://pubs.acs.org/doi/full/10.1021/ja102148f?cookieSet=1

Scientists are reporting the first evidence that a polymer antibody — an artificial version of the proteins produced by the body's immune system to recognize and fight infections and foreign substances — works in the bloodstream of a living animal. The discovery is an advance toward medical use of simple polymer nanoparticles custom tailored to fight an array of troublesome "antigens." A team led by Yu Hoshino and Kenneth Shea of the University of California at Irvine developed a method for making polymer nanoparticles that mimic natural antibodies in their ability to latch onto an antigen, melittin, the main toxin in bee venom. They make the antibody using molecular imprinting. They established that these polymer melittin antibodies worked like natural antibodies in mice. The animals that immediately received an injection of the melittin-targeting polymer antibody showed a significantly higher survival rate than those that did not receive the nanoparticles.

AFM tip 'writes' conducting graphene nanowires

http://physicsworld.com/cws/article/news/42906

The interface within devices between conductors, semiconductors, and insulators is usually created by stacking patterned layers of different materials. For flexible electronics, it can be advantageous to avoid this architectural constraint. Graphene oxide, formed by chemical exfoliation of graphite, can be reduced to a more conductive form using chemical reductants. A US group now show that layers of graphene oxide can also be reduced using a hot atomic force microscope tip to create materials comparable to those of organic conductors. This process can create patterned regions (down to 12 nanometers in width) that differ in conductivity by up to four orders of magnitude. The technique is precise, which means that the rest of the graphene oxide sample remains insulating. Writing with different tip temperatures, from 130 °C upwards, also allows the electronic properties of the nanowires to be tuned over four orders of magnitude, making the wires more or less conducting. The process is known as thermochemical nanolithography.

The original paper is in Science:
http://www.sciencemag.org/cgi/content/full/328/5984/1373).

Performance of graphene monolayer nanocomposite

http://www3.interscience.wiley.com/cgi-bin/fulltext/123441305/HTMLSTART

A new study by a group at the University of Manchester suggests that

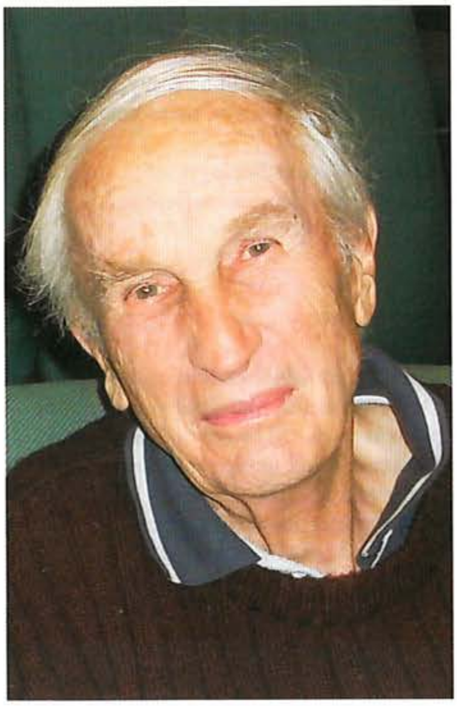
continued p 90

Obituary

John de Laeter

03/05/1933 - 16/08/2010

by David Blair



On 16 August 2010 Western Australia lost John de Laeter, a teacher, a citizen, a physicist, a leader, a Christian, a sportsman, a hero and a national treasure. His life was an inspiration - in another era he would have been made a saint. His work touched the lives of almost every West Australian.

From humble beginnings John won a scholarship to Perth Modern School. He then studied under a teaching bursary, and taught at high schools and Perth Technical College. At a science teachers conference in Sydney a debate on the origin of the universe inspired him and changed his life. He enrolled for a PhD at the University of Western Australia under mass spectroscopist Peter Jeffery and he remained active in this field for the rest of his life. John applied mass spectrometry across astrophysical, chemical, geological, environmental and nuclear problems. He wrote more than 200 papers, often with co-workers from the mass spectrometry centre at Curtin University that was named in his honour. Papers ranged across areas from metrology to geochronology, cosmochemistry, nuclear science and geochemical analysis. He dated the earth's mantle and explored the extremities of the solar system through meteorite analysis. He was a member of the Atomic Weights Commission of International Union of Pure and Applied Chemistry. He joked that he was responsible for the atomic weights of 12 elements. On the morning of his departure for the June 2010 meeting of the Atomic Weights Commission a rapidly developing tumour was diagnosed and he was forced to cancel his trip.

During the past 15 years I had the privilege of working very closely with John on the creation and development of the Gravity Discovery Centre, the public outreach centre for our gravitational wave research facility at Gingin, 80km north of Perth. Writing this obituary I was astonished to discover the quantity, range and depth of the papers he was writing at times when I thought he was entirely occupied with our joint project - papers including a study of isotopes in the Oklo natural nuclear reactor, stellar nucleosynthesis processes, the geochronology of Australia, meteorite age determinations and a beautifully illustrated book on meteorites with Alex Bevan of the WA Museum.

John was always modest and self-deprecating. However, behind that modest personality was a driving vision for a strong scientific community in WA. He used his enormous energy and brilliant time management to turn that vision into reality. He believed that in our isolated corner of the world Western Australians could make a difference. He believed overwhelmingly in the power of education and science to create a better world. He was very concerned about the demise of science and technology in Australia, including the quality of teaching. He wrote a series of papers on enrolment trends in science and was amongst the first to note the decline in physics enrolments from about 1992. In a paper published in the ANZAAS magazine Search (Vol 47, 1996, with John Dekkers) he wrote: "the signal from secondary school science enrolment data is that a rapidly decreasing proportion of students are preparing themselves for careers in engineering, science and technology. There is also some evidence... that the quality of young people entering these courses is not as high as in the past".

John was always looking for initiatives that could help turn around the decline. He looked at the big picture, always aimed high, and clocked up an astonishing range of achievements. On the way he occasionally but memorably locked horns with government. His passions were always aroused by shortsighted government decisions. First, in 1960 at a speech when he received a teaching award, John publicly criticised and embarrassed the WA government for the woeful state of the Perth Technical College. He advocated a new technological institution. His speech helped trigger the establishment of the WA Institute of Technology, now Curtin University, where he became Head of Physics at age 34, and later deputy Vice-Chancellor. He went on to help establish WA's Technology Perk, The Curtin Science and Mathematics Education Centre, and Scitech Discovery Centre. A few years ago John threw his weight behind the proposal for the SKA project to be sited in Western Australia. During the planning the proponents suddenly discovered that a road was being put in right across their proposed site on Mileura Station. John was furious. He campaigned intensely and successfully for a solution, which led to the creation of the Murchison Radio Astronomy Observatory site at Boolardy Station. When I asked John if he would help plan the Gravity Discovery Centre he accepted without hesitation. He chaired the planning committee and then the board of the Gravity Discovery Centre Foundation. We raised funds together and then constructed domes, towers, galleries and a public observatory. John loved the GDC for its science combined with art, environment and traditional beliefs and especially for its broad focus on the big questions of the universe, the very topic that brought him into physics research. The GDC won John and myself the Eureka Prize for Promoting Science. However early in 2010 it was threatened with closure by our then Minister for Science Troy Buswell. This shortsighted decision again raised John's passions and for the first half of this year he gave enormous and unstinting energy to reversing the decision. He tried to work quietly behind the scenes but in April 2010 a radio talkback caller asked the WA Premier about a rumour of imminent closure of the GDC. Forced to go public, John's passion was not abated. He took up the issue with fiery radio and television interviews. His actions unleashed huge public support including a petition to the WA Parliament. One month later, at his last board meeting, John was able to announce government support from the new Minister for Science, Bill Marmion. Despite his passions John was never an antagonist.

He always created constructive relationships, especially between Universities, Government and Industry. Besides his work as a scientist and educator, John was a devoted sportsman, a practicing Christian and a devoted family man supported by a devoted wife Robin. John excelled in tennis and hockey, captaining teams and playing regularly until a month before he died. He was a lay preacher and gave sermons on science and the bible. He lived his Christian values but was quite undogmatic and fully embraced the juxtaposition of scientific cosmology and multicultural cosmology at the GDC.

John received multiple awards including the Order of Australia. He was the 3rd inductee into the WA Science Hall of Fame along with two Nobel Prize winners. He was a bit embarrassed about the naming of Minor Planet de Laeter 3893, and was always quick to say, "it's only a minor planet".

I thank John's son Mark for his help.

Branch News

Victoria

Bright Future for Diamonds

In June the Victorian branch hosted a presentation by Dr Andy Greentree from the School of Physics at the University of Melbourne. His talk covered the properties of diamond, and some of its history, before outlining the future for diamond in twenty-first century technology.

Diamond is a remarkable material. Its clarity and hardness have made it sought after for decorative and lithographic applications since antiquity. But some of its other properties are exciting the community, and with the new and improved fabrication techniques for synthetic diamond, a new diamond vista is emerging.

Andy described four ages of diamond. The first age described diamond from antiquity to the early 20th century. In this era diamonds were found or mined, and either used for decoration, or for polishing. Indeed some early stone tools show markings consistent with diamond polishing. In the twentieth century, especially with the manufacture of cheap synthetic diamonds after the Second World War, diamonds became increasingly used for drilling and polishing applications. This constitutes the second age of diamond: with diamond used to drill into rocks and teeth. The third age of diamond is the present. This age is defined by access to high purity, reproducible synthetic diamonds. These diamonds have applications in electronics, as optical windows, and scalpel blades. Now for the first time, reproducible diamond substrates are available and realistic technologies can be envisaged.

Fig. 1. Dr Andy Greentree and the prospects for new diamond technologies.

We are rapidly moving into the fourth age of diamond: advanced diamond. Andy outlined applications for diamond in the quantum realm. These included single photon sources for quantum cryptography, microfluidic channels in diamond, and the bionic eye. In the biospace, biocompatibility of diamond makes it a material of choice for the electrode array in the bionic eye, and as a coating for prosthetics. In the quantum space, diamond is the host for colour centres, which act as artificial atoms with high brightness. One of these, the nitrogen-vacancy colour centre, is the only known solid-state room temperature single photon source, and has demonstrated room-temperature single spin readout and quantum coherence. Major challenges include the sculpting of diamond to create optical structures, and the precise placement of these colour centres at defined locations in the crystal.

With an explosion of interest and effort world-wide, and a concentration of activity in Australia, the prospects for new diamond technologies look very bright indeed.

Loud and Clear for Bionic Ears

In July the Victorian branch organised a visit to the Bionic Ear Institute in East Melbourne. The Deputy Director, Professor Peter Blamey, presented an overview of the current research programs at the Institute. It is now over 30 years since Graham Clark developed the first cochlear implant or 'bionic ear'. The bionic ear has enabled hearing for over 150,000 people worldwide, making it probably the most successful of all medical bionic devices. This Australian invention generates over $500 million each year in export income. Despite this success, the bionic ear still has some shortcomings, particularly its performance in noisy environments, in the appreciation of music and in the perception of tonal languages. A significant part of the Institute's research aims to overcome these problems by developing a new generation of high-fidelity bionic ears.

Recently, the Institute decided to expand into the broader area of medical bionics. It is one of several partners in Bionic Vision Australia which was launched in November 2008. Bionic Vision Australia is developing an advanced bionic eye to improve the sight of people suffering from eye diseases, such as macular degeneration which is responsible for almost half of all blindness in Australia. A miniature video camera fitted to a pair of glasses is under development which will capture and process images. These images are sent wirelessly to a bionic implant at the back the eye that stimulates dormant optic nerves to generate points of light, which then form images in the brain.

Peter concluded his talk with a summary of the other research programs at the Bionic Ear Institute. These include the development of new techniques for the delivery of therapeutic drugs that may prevent nerve degeneration and even promote regrowth. Another promising area is the development of techniques to

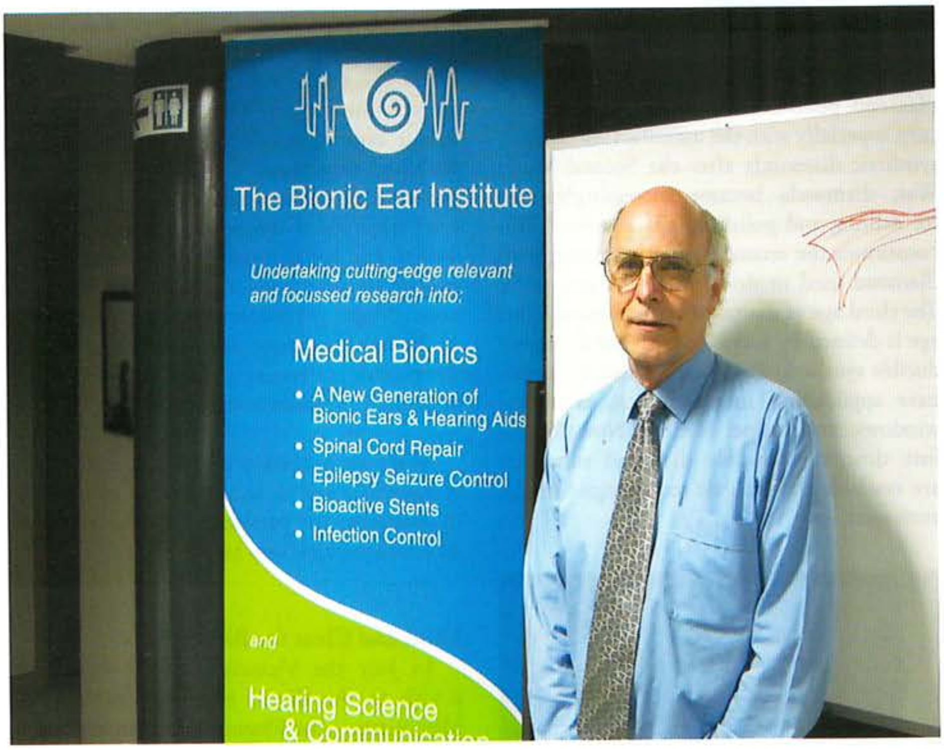


Fig. 2. Professor Peter Blamey, Deputy Director of the Bionic Ear Institute.

stimulate nerves selectively in the brain and spinal cord, which could find applications in the treatment of epilepsy and traumatic injuries such as paraplegia and phantom limb pain. Advances in these new areas are expected to feedback into the Institute's principal area of research and lead to even better bionic ears in the future.

Mini black holes at the LHC

The August lecture to the Victorian Branch was presented by Elizabeth Winstanley, the 2010 AIP Women in Physics lecturer. Elizabeth completed a DPhil in theoretical physics at Oxford in 1996. After her doctoral studies, she was appointed a lecturer in Applied Mathematics at Oriel College, Oxford University, teaching a wide range of mathematics and theoretical physics courses. In 2000 she joined the Department of Applied Mathematics at the University of Sheffield and was promoted to Professor of Mathematical Physics in January 2009. She has a keen interest in developments in mathematics and science education and has served on a number of national mathematics education committees in the UK.

Elizabeth's research interests lie in general relativity, quantum gravity and quantum field theory in curved space-time. Her research focuses on the physics of black holes, particularly 'hairy' (and more recently, 'furry') black holes in general relativity and the Hawking radiation of black holes that might be produced at the Large Hadron Collider at CERN in Switzerland. Brane world models in string theory suggest that our universe is a slice, or 'brane', of a higher-dimensional space-time. Elizabeth discussed why one consequence of these models is that copious numbers of mini black holes may be formed by collisions at the LHC. She described how these mini black holes might be created, and what happens to them once they have been produced.

There has been widespread and misguided public concern that any mini black hole created at the LHC will grow and swallow up the entire Earth. Elizabeth put forward two reasons why this cannot happen. The first is that Hawking radiation from the mini black holes means that their lifetimes are infinitesimally short. Even if the Hawking theory is wrong, there is an even more convincing reason. Cosmic rays far more powerful that the protons accelerated in the LHC have been striking the Earth throughout its history. If mini black holes could grow out of control, we would not be here to discuss it!

News from AIP VIC Branch were provided by Mr Peter Robertson.

Tasmania

The Branch has held two public events since the previous report. On May 13th we heard an interesting talk by Dr John Innis, Senior Scientific Officer at the EPA Division of the Tasmanian Department of Primary Industries, Parks, Water and Environment, discussing the creation and initial operation of BLANkET - the Base-Line Air Network of EPA Tasmania.

For many years atmospheric smoke pollution has been an endemic topic in Tasmania every autumn, often sourced from fuel reduction and forestry regeneration burns. Discussions are one thing, quantitative observations are another and until recently ambient air quality monitoring was confined to Hobart and Launceston, in particular monitoring has largely focussed on winter wood-smoke pollution trapped below inversion layers in the Tamar Valley. The need for more widespread observations became evident and the first five stations of the BLANkET network were commissioned in May 2009. The network now has fifteen operating stations. Some are located in areas liable to smoke following controlled and un-controlled burns; others also monitor locally produced smoke from wood-heaters and other sources, as well as providing information on larger smoke events. The aim is to get reliable information on the distribution of pollution particles, particularly PM2.5, particles up to 2.5 microns and PM10, particles up to 10 microns (including, of course, PM2.5).

Local events are often related to katabatic winds funnelling down reasonably nar-

Fig. 3. Elizabeth Winstanley, University of Sheffield, the 2010 AIP Women in Physics lecturer.

row valleys. John described one such event when smoke from a fire inland from Burnie was detected in Burnie and Cooee, coming down the Emu River valley, but not at nearby Somerset where it would have come down the

adjacent Cam River valley.

Other events are apparent both on regional scales, such as across the Huon Valley in mid April 2010, and over greater areas. In mid-March this year the northern Tasmanian air stations recorded strong signals during northerly winds where the smoke was evidently coming from fuel reduction burns in Victoria. John's animations showed particle concentrations dropping abruptly at all stations when the wind changed. The network also detected a dust event on 12th of September last year, when dust from the Simpson Desert reached Tasmania. This event occurred about 10 days before the major 'red dawn' dust storm that affected Sydney and Brisbane.

Most recent (delayed by only a few minutes) PM10 and PM2.5 concentrations are now available on-line for all fifteen BLANkET stations and the four major Tasmanian air stations. For the major stations, one in Hobart and the other three in the Tamar Valley, time trends for the current day are also available.

The data obtained from BLANkET provides air quality information to the public and to planned burn managers, and is providing detailed information about the movement and dispersion of smoke in the Tasmanian airshed. The Tasmanian Forest Practices Authority has been trialling a Co-ordinated Smoke Management System, a voluntary system which places a quota on daily requests for fuel reduction and forest regeneration burns. BLANkET is providing quantitative data that will assist in assessing the effectiveness of the CSMS. BLANkET is also providing some very interesting data on wintertime smoke levels from domestic heating in certain Tasmanian towns. John's audience were left with a much better understanding of an important local topic. It was a most informative evening.

As part of its annual scientific meeting, the Astronomical Society of Australia holds a public lecture in memory of its first President, Dr Harley Wood. The 2010 ASA meeting was held in Hobart and the AIP's Tasmanian Branch co-sponsored this year's lecture, given on July 6th by Professor Elaine Sadler from the University of Sydney. Her title, Adventures in Wide Field Astronomy, had us wondering where she might lead us. A fascinating tour it turned out to be. A decade ago, the Canadian astronomer Sydney van den Bergh predicted that "astronomy of the 21st century will be dominated by computer-based manipulation of huge homogeneous surveys of various types of astronomical objects." In many ways this has come true, and Elaine treated her audience to a range of analyses based on a wide variety of observations. The advent of wide-field observations both at optical and radio wavelengths has greatly increased the quantity of high quality data available for analysis. Combined with increases in computational capability, this has enabled the evolution of galaxies to be studied in a comprehensive fashion.

Elaine pointed out the major stages in arriving at this situation. In the 1880s it was thought that the Milky Way might represent the entire universe, and it was only in the 1920s that Harlow Shapley showed that other galaxies lie beyond. Now we identify millions of galaxies and believe we know the age of the universe to three significant figures.

The time taken for light to reach us from the furthest observable galaxies means that we see them in a relatively young state. By comparing their average properties with those of closer galaxies, which are likely to be older, it is possible to obtain insight into galactic evolution. It's likely that all massive galaxies go through a radio phase as they evolve. Their central black holes regulate the rate of new stare formation. In the local universe, star formation is estimated at around 10 solar masses per year.

News from AIP TAS Branch were provided by Dr John E Humble.

New South Wales

The June meeting of the NSW AIP branch was held at the University of Sydney on Tuesday the 29th of June 2010. The invited speaker for the meeting was Dr Susanna Guatelli, with research activities in Medical Radiation Physics. Dr Guatelli has completed her PhD in physics at University of Genova, Italy. Her main research activities are in the field of Monte Carlo simulations in radiation physics with application of the GEANT radiation transport code. She has completed research at CERN in the simulation of monitoring radiation detectors for HEP and radiation shielding of spacecraft for space exploration missions as well as in dosimetry for IMRT, brachytherapy and Proton Therapy. Dr Guatelli first came to Australia as a post-doctoral fellow with the Detector Group at ANSTO, led by Dr Mark Reinhard. Since March 2009, Dr Guatelli has been a lecturer within the School of Engineering Physics at the University of Wollongong, performing research at the Centre of Medical Radiation Physics (CMRP), led by Prof Anatoly Rosenfeld.

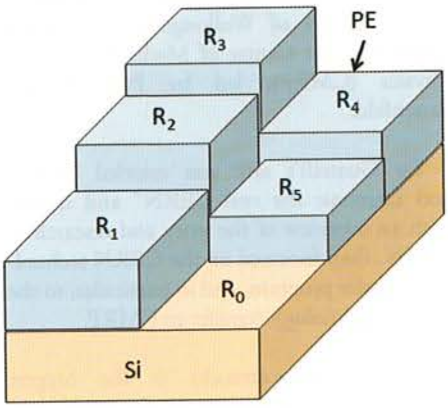
Dr Guatelli's talk was entitled "Angels and Demons: the real CERN" and started with an overview of the story and research of CERN, then focussed on the CERN technology transfer program, and in particular, to the CERN technology transfer to CMRP.

CERN (www.cern.ch) is the biggest nuclear physics laboratory in the world, had its beginnings in 1954, with the mission of performing fundamental research in physics, developing advanced technology, enhancing collaborations among scientists of different nationalities, and training the scientists of the future. Nowadays CERN research is mainly devoted to High Energy Physics (HEP), with the Large Hadron Collider (LHC) experiment, involving research institutes from 85 different countries. The main goal of LHC is to answer the unresolved questions of the Standard Model: investigate high energy collisions, detect the Higgs boson, investigate dark energy and dark matter, understand the asymmetry between matter and antimatter.

While the attention of the media is focused on the CERN fundamental physics research, much less attention is dedicated to other CERN domains of activity such as the CERN Knowledge and Technology Transfer program that covers a crucial role in CERN policy

Fig. 4. From left to right, Dr Frederick Osman, Dr Susanna Guatelli, Dr Michael Lerch and Chen-Yu Huang.

(http://technologytransfer.web.cern.ch/technologytransfer). This program includes the transfer of technologies developed at CERN to other domains of research, such as medical physics, space science, information technology, and industry.



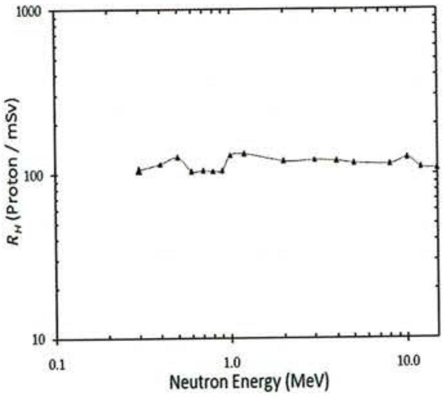


Fig. 5. a) Sketch of the fast neutron, energy independent, dosimeter, consisting of Medipix2 pixelated detector, complemented by structured polyethylene converter with 3D shape optimized by GEANT 4 b) Simulated by GEANT 4 dose equivalent response of finally designed neutron dosimeter (*3*).

Geant4 (www.cern.ch/geant4) is a Monte Carlo Simulation Toolkit, modelling the interactions of particles with matter. Geant4 was originally born for High Energy Physics, with functionality adequate to LHC experiment studies. Thanks to the advanced software technology solutions adopted, Geant4 was easily extended to other domains, as space science and medical physics, by including physics models devoted to low energy domain (*1, 2*). Nowadays Geant4 is widely used in Medical Physics studies, from proton therapy to brachytherapy, IMRT, to optimise the radiotherapy treatments and to verify the accuracy of the treatment planning systems, adopted in hospitals. Geant4 is widely used also in the characterisation and optimisation of novel detectors, and in radiation protection for shielding simulations.

Geant4 is widely used at CMRP, as a Monte Carlo simulation code in dosimetry, microdosimetry and nanodosimetry, to enhance and characterise radiotherapy treatments, and to study novel detectors, developed at CMRP. Dr Guatelli's talk then focused on the description of some Geant4-based research activities, performed at CMRP, managed by Dr Guatelli.

Dr Guatelli presented CMRP research on the development of a fast neutron, energy-independent tissue equivalent dosimeter under development for radiation protection and space missions particularly, described in detail in (*3*). The neutron dosimeter consists of a pixellated silicon detector, Medipix2 (*4*) complemented by a special design structured polyethylene converter, as shown in Figure 1.

The modelling of the response of the MEDIPIX 2 covered with structured polyethylene converter with GEANT 4 allowed adjustment of the 3D shape of the converter to make response of the dosimeter, in terms of tissue equivalent neutron dose, energy independent and gamma photon insensitive. Such dosimeter is portable and designed for space missions for astronauts to monitor the biologically relevant neutron dose.

Geant4 is widely used at CMRP to study other novel detectors, as Silicon-On-Insulator (SOI) microdosimeters (*5*) first solid state microdosimeter able to measure the radiation dose deposited at the cellular level, in any mixed radiation field, and derive the dose equivalent based on microdosimetric spectra. The development of this detector started more than 10 years ago at CMRP, and it was optimised using Geant4 simulations.

Geant4 was used at CMRP to simulation in proton therapy, fast neutron therapy, and radiation protection in earth labs, in aviation and space (some of them can be found in (*6-10*)). Fundamental characteristics of SOI microdosimeters, such as tissue equivalence, was characterised by means of Geant4 (*11*). Silicon is not tissue equivalent and a methodology was developed to convert microdosimetric spectra in silicon to water, in proton radiation fields of interest for proton therapy and radiation protection in Low Earth Orbit (LEO) studies. In this study it was found that a simple geometrical factor scale (approx 0.56) is adequate to convert microdosimetric energy deposition spectra in silicon to equivalent energy deposition spectra in water, along the Bragg curve, when the proton field has an energy range between a few MeV and 250 MeV. It was in a good agreement with CMRP earlier works for alpha particles and heavy ions (*12*). At present at CMRP we are developing a generic algorithm for conversion of microdosimetric spectra in silicon to water, for any mixed radiation field, consisting of protons, alpha particles and energetic ions typical of the deep space radiation environment.

A very interesting study performed at CMRP, by means of Geant4, is to investigate possible magnetic field enchanced radiobiological effects in radiation therapy, in order to improve the effectiveness of the radiotherapy treatment. The hypothesis of this study relies on the fact that:

- early damage to cells by radiation starts with the early damage in the DNA helixes, determined by the microscopic pattern of energy deposition (number of ionizations) on DNA level; the number of Double Strand Breaks in DNA helix is correlated to this pattern;
- for any kind of ionising radiation, about 80% of the deposited energy to tissue is due to low energy (delta) electrons (E < 10 keV);.
- changing spatial distribution of low energy electrons in a magnetic field can change clustered damage of DNA without changes to the absorbed dose.

Towards this aim, the CMRP MC Group is investigating the application of Geant 4 for simulation of clusters of ionizations in the nuclesome and DNA modelled in water as presented in Figure 5a. For benchmarking Geant 4 with such low energy electrons, transport in water in comparison with the Physikalisch-Technische Bundesanstalt (PTB) established low electron energy Monte Carlo code has been done. Mean ionization cluster size with respect to the initial electron energy for the DNA segment and the nucleosome, calculated by means of the Geant4 and PTB codes presented in a Figure 5b suggested good agreement of the two codes. The advantage of Geant 4 in comparison with the PTB code is in the possibility of performing simulations in the presence of magnetic field. The effect of a magnetic field on direct ionization in the DNA and nuclesome has not shown essential RBE enhancement and other mechanisms are under investigation. This work is continuing in collaboration with PTB, Germany, LLUMC USA and ANSTO. More details of this preliminary simulation work can be found in (*13*).

Another example of the application of Geant 4 at CMRP in the simulations of radiation therapy in the presence of magnetic fields can be found in (*14*) where modification of the skin doses was predicted in conditions on MRI guide radiotherapy on medical LINAC. Geant 4 was also applied at CMRP for simulations of the response of edge on MOSFET dosimeters in Microbeam Radiation Therapy (MRT) (*15*) where dose pattern on micron scale level is of interest. This direction of research is important for Australian

synchrotron medical beamline where an MRT facility is being built.

Recently essential progress have been achieved at CMRP jointly with LLUMC and University of Haifa in proton computer tomography (pCT) where a new algorithm for image reconstruction was developed utilizing GEANT 4 simulations and the "Most Likely proton Path" (MLP) formalism for protons coming through the tissue (*16, 17*). The recorded experimental data, and similar data set generated by GEANT4 based MC code simulating the experimental set-up for pCT in LLUMC, were treated by 3D image reconstruction software exploiting algebraic reconstruction technique (ART) combined with the MLP concept given in the Appendix of (*16*). Reconstruction results presented as the transversal cuts of the 3D image of the phantom are shown in Figure 6. This work was fulfilled mostly by Scott Penfold and was possible originally due to strong Geant 4 training at CMRP with active participation of Dr Guatelli.

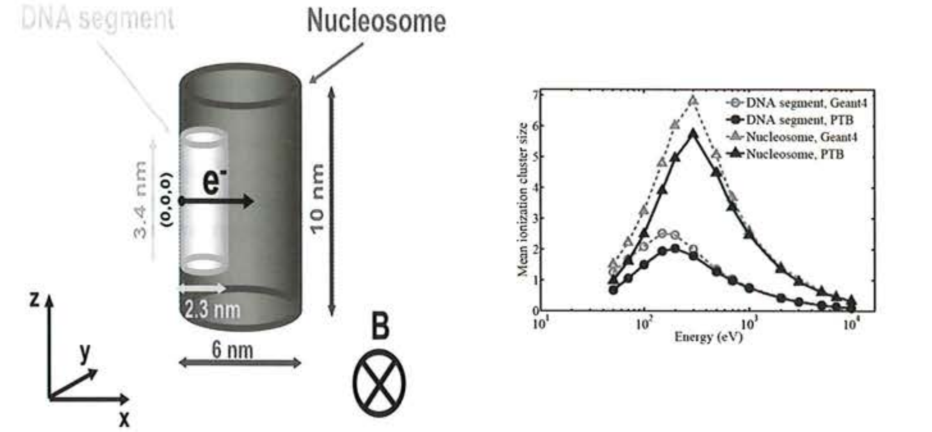


Fig. 6. a) Geometrical set-up of the Monte Carlo simulations including the direction of the magnetic field in the Geant4 simulation. The nucleosome and DNA segment models were embedded in water; b) Mean ionization cluster size with respect to the initial electron energy for the DNA segment and the nucleosome, calculated by means of the Geant4 and PTB codes without magnetic field. (*13*)

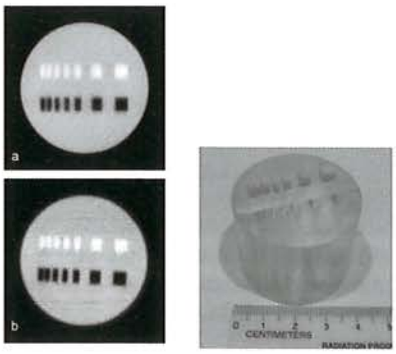


Fig. 7. Transversal cuts of the 3D phantom image reconstructed from (a) simulated with help of Geant 4 and (b) experimental data c) Acrylic phantom. The upper row is filled with bone-equivalent plastic, the lower row is empty.

In her talk, Dr Guatelli also dedicated a few words to her experience teaching Geant4 to undergraduate and postgraduate students, at the School of Engineering Physics of University of Wollongong, in a laboratory hands-on course, documented in [18]. Students were engaged in the work and understood the importance of the adoption of Monte Carlo method in physics, however they were frustrated by the computing difficulties encountered, given the absence of a significant computing background. Strategies have been identified to improve the course, as *i.e.* providing a web page, with pre-lab documentation, re-structure of the course, with higher number of laboratory hours, to teach basic computing programming to students.

In conclusion Geant4 was born at CERN for HEP experiments, and then was extended to other domain of research, as medical physics and space science. In particular at CMRP, Geant4 is widely used for dosimetry in conventional and proton therapy, microdosimetry, nanodosimetry, different detector response and proton imaging, counting on a large research group within the Centre for Medical Radiation Physics at the University of Wollongong, consisting of three staff members and about 10 Master/PhD students.

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News from AIP NSW Branch were provided by Dr Michael Lerch.

The revolution is coming

Quantum Mechanics in the 21st Century

by Stephen D. Bartlett, Michael J. Biercuk, Andrew C. Doherty, and David J. Reilly

Introduction

The future of technology lies in controlling the quantum realm. Our understanding of the basic principles of quantum mechanics has produced the technology that shapes our daily lives; without quantum mechanics there would be no computers and no internet. However, the materials and devices that are the building blocks of the modern information economy have quantum properties that are naturally occurring. Moreover, they do not yet make use of the most exotic quantum effects that have intrigued scientists since the inception of the field.

Rather than simply take what we find in Nature, can we engineer the quantum world for our purposes? Can the strangeness of quantum mechanics be used as a new and untapped resource?

From Quantum Mechanics to Quantum Science

Quantum mechanics gradually developed as a mathematical framework for the description of matter on the atomic scale. Although it was cobbled together from the work of a number of independent scientists, essentially all phenomena at the microscopic scale, including the orbitals of electrons around an atom, atom-photon interactions, and the statistics of electrons in solids, have been elegantly described using this formalism. To date, quantum mechanics represents our most accurate and widely applicable scientific theory, predicting technologically relevant phenomena such as semiconductor bandstructure, lasing, and superconductivity. All told, quantum mechanics has already enabled a quantum revolution, supporting the development of an entire generation of technology that has given us the modern information economy.

However, the quantum mechanics that we encounter daily in devices like semiconductor electronics or lasers incorporates only the most basic phenomena. These systems behave semi-classically – possessing quantum characteristics such as discrete energy levels and quantum statistics, but lacking any signatures of quantum coherence or phase information. The most exotic behaviours such as quantum superposition and entanglement that have so intrigued and confounded physicists are rapidly lost through coupling to a noisy environment, spontaneous emission, and the like. Most importantly, these devices make use of bulk properties where quantum coherent effects are masked by ensemble averaging over large numbers of incoherent quantum systems.

The past two decades have seen an explosion in the number of systems that have been able to provide a window from our classical world to the world of quantum coherence. This research has been undertaken in a number of disciplines that have developed largely independently; condensed matter physics, superconductivity and strongly correlated systems, atomic, molecular, and optical physics, and nuclear magnetic resonance, among others. Remarkably, in each of these disparate fields experiments have demonstrated that it is possible to realize and manipulate quantum mechanical degrees of freedom such as photon polarization, the flow-direction of supercurrents, the location or spin-state of an electron, or the vibrational mode of individual trapped atoms.

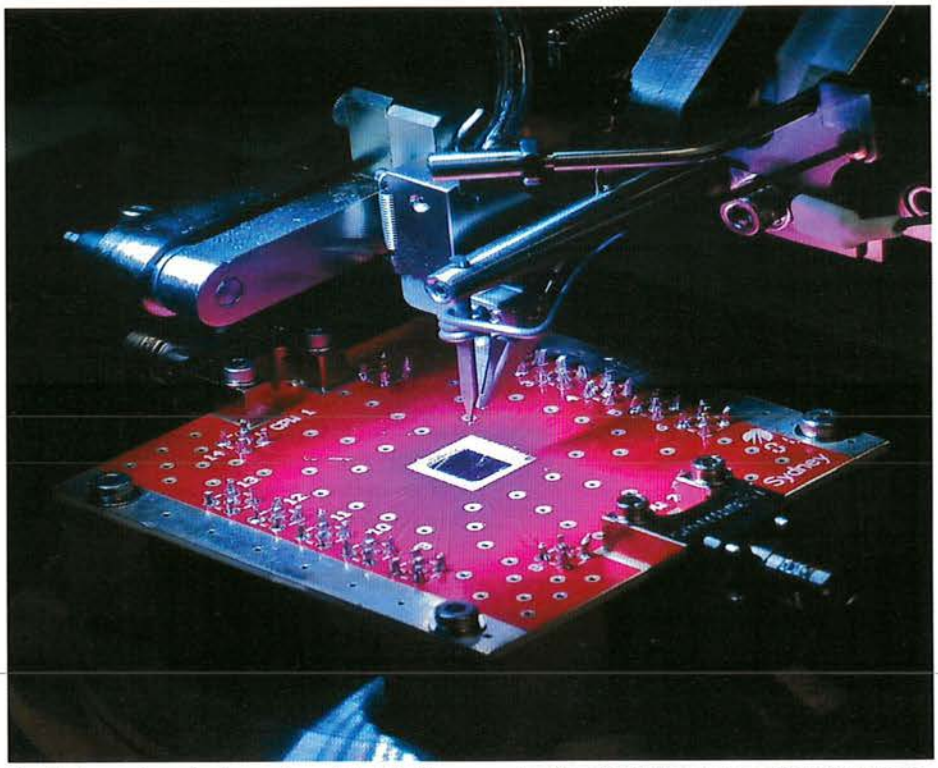

Fig. 1. A semiconductor spin-qubit chip is connected to a high-frequency circuit for quantum measurement and control. Quantum systems based on single spins are a key research thrust of the Mesoscopic Physics Laboratory at the University of Sydney.

These experimental capabilities have led to a renaissance in quantum physics, allowing us to realize in the lab some of the most exotic gedanken experiments from the early days of quantum theory: wave-particle duality, the Einstein-Podolsky-Rosen paradox, and Schrödinger's cat. Moreover, the realization of coherent quantum control in these systems has led to a convergence of previously independent fields: a rediscovery of atomic physics in artificial atoms and other condensed matter systems, the modeling of superconducting circuits using the principles of quantum optics, the development of micro and nanofabricated atom-chip platforms.

More importantly, this recent work has led to the prediction of the imminent arrival of a second quantum revolution, one in which we shift away from implicitly leveraging the quantum-mechanical nature of matter, towards explicitly exploiting and controlling the quantum realm. We are now seeing the early development of a new class of technologies that use the strangest phenomena in the quantum world as resources to enable fundamentally new ends. Early research focused almost exclusively on computation and communications, but it has been realized that the landscape of potential applications is far broader than originally conceived.

Pioneering researchers ushering in this second quantum revolution have historically emerged from the various disciplines described above, but today, Quantum Science

has emerged as a worldwide initiative and a substantive discipline of physics. The field now has hundreds of active research faculty across the globe, and literally thousands of young researchers and students. It spans experiment and theory, and focuses on new techniques and applications involving the realization and coherent control of quantum mechanical degrees of freedom, often from mesoscopic systems (*e.g.*, ensembles of atoms behaving in unison, or superconducting currents composed of many electron-pairs).

Where is the field going?

The second quantum revolution appears to be well on its way. The past decades of research have positioned the field such that today there exists a vast array of research areas with the potential to dramatically alter the course of technology. Here we present a few topics that appear poised to make a splash.

Hybrid Quantum Systems

In its primary stages Quantum Science has focused on the demonstration and control of quantum coherent phenomena in a variety of platforms, often using technology-specific techniques in the process. Frequently, a particular experimental platform has great strengths traded off against intrinsic limitations. For instance, the integration of solid-state quantum devices such as quantum dots provides benefits in scaling and communications, but limitations in coherence time – the effective lifetime of the system's "quantumness" – due to the strong interaction with "dirty" substrate materials.

Recent technological developments have shown that it is possible to engineer hybrid quantum systems that in many instances marry the best features of two or more worlds. For instance, experiments focused on superconducting devices have shown that it is possible to produce a quantum two-level system in a circuit that is coupled to a microwave resonator; the composite system is well described using the language of the quantum-optical cavity-QED paradigm. Here, a solid-state circuit is coupled to microwave-frequency photons in order to provide improved aggregate performance and fundamentally new capabilities.

This trend is set to continue; ultimately, quantum systems are likely to employ an array of interacting quantum components, each contributing specific capabilities and producing new behaviour at the system level. This paradigm appears all the time in the macroscopic world around us. For instance, a CD player is a classical exemplar of a complex engineered system incorporating mechanics, optics and opto-electronics, precision measurement and feedback control, information processing, and error correction. Similarly one may envision complex engineered quantum systems, providing tremendous new capabilities, but requiring coupling between different platforms in a hybrid package. The unification of seemingly unrelated technologies thus holds great promise, and will be generating a lot of attention in the next few years.

Quantum Control and Measurement for Robust, Large-Scale Quantum Systems

As contemporary technologies evolved from individual devices to complex systems, it became necessary to move beyond coarse and "manual" control methods. Similarly, these systems had to function in the presence of noise and faulty parts. Robust, efficient, and automated control mechanisms are an absolute requirement at the system level, and these needs have given rise to the modern field of optimal control theory. The same motivations emerge in the quantum realm, making control theory an ideal starting point for the creation of a quantum analogue.

Methods of quantum control and measurement are at the core of our capacity to construct new technologies from quantum building blocks. A key research area in quantum science focuses on the theoretical and experimental development of protocols providing fast, resource-efficient manipulation and readout of quantum systems. Techniques from modern control theory can be adapted to quantum systems, as long as we take care to properly include the effects of quantum measurement. Such considerations dramatically impact the landscape of accessible control techniques.

A good example is hardware robustness against error. Error-resistance is desirable in any technology, whether in relation to information processing or metrology. In quantum systems, direct adoption of standard measurement-based feedback protocols is excluded on its face because of their reliance upon periodic interrogation of the target system and the resultant collapse of superposition states. However, a new class of open-loop control techniques known as dynamical decoupling provides a means to suppress errors without the need for measurement, and the clever assemblage of parity checking operations and measurements on ancilla systems has produced the modern field of Quantum Error Correction.

Beyond developing "useful" procedures, however, there is also a need for the development of control and measurement techniques operating at the absolute limits imposed by quantum mechanics. For example, noise due to quantum statistics in semiclassical states sets a limitation on the achievable precision of a measurement. However, by manipulating systems into more exotic quantum states using control theoretic approaches, this quantum noise can be shunted into irrelevant degrees of freedom, with a potentially dramatic improvement in measurement precision.

Synthetic Quantum Systems and Simulation

Quantum science is poised to develop extendable quantum systems with tunable interactions through the combination of elementary building blocks at the microscopic level. Theory can guide us to understand some equilibrium properties of many body systems, but amazingly, the physics of such strongly coupled, individually addressable, many-body quantum systems is largely unknown and essentially inaccessible to existing numerical simulation techniques. This includes many of the most exciting conditions such as highly entangled many-body states and exotic states of matter with hidden, long-range quantum order.

New states and phases of matter that can be used to build quantum technologies may be achievable in a wide variety of strongly correlated quantum systems, or may be synthesized in designer hybrid systems to exhibit a variety of desired properties. Ultimately, producing and characterizing this "quantum matter" will lead us to new regimes of physics, with emergent phenomena arising in such interacting systems that are very different from those observed in their component systems.

Aside from simply accessing new regimes of physics, however, is the possibility to produce controllable simulators of other complex quantum systems. Leveraging tunable interactions and independent control over constituent quantum systems one may realize what amounts to a universal quantum simulator. This has the potential to impact the field of condensed matter physics and strongly correlated systems, but may also simply provide a useful computational tool for modeling the interactions of large ensembles. For example,

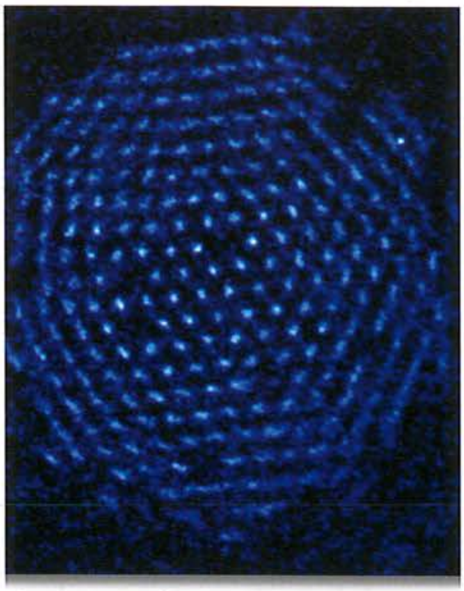

Fig. 2. A two-dimensional Coulomb crystal of laser-cooled Beryllium ions. The regular crystal structure, spin-control mechanisms, and techniques for producing tunable coupling make this system an ideal candidate for studies of quantum magnetism and exotic large-scale entangled states. Courtesy US NIST and the Quantum Control Laboratory, Sydney.

quantum many-body systems with controllable interactions may be used to simulate the Hubbard model and other candidate models for high-temperature superconductivity that currently elude extant numerical calculations. Such simulations may ultimately be a fundamental tool in the production of new designer materials.

"Can we engineer the quantum world to our purposes? Can the strangeness of quantum mechanics be used as a new and untapped resource?"

Quantum Metrology and Sensors

Physical systems that are strongly governed by quantum effects can serve as exquisitely sensitive detectors. "Quantum enhanced" sensing and metrology, including the ability to probe or image single electron and nuclear spins or the measurement of single quanta in mechanical systems, is a fundamental and enabling capability that could lead to breakthroughs including probing of biological and quantum mechanical phenomena in liquids and solids, the noninvasive imaging of proteins and drugs in-vivo, and ultimately the development of a deep understanding of our world at the atomic scale.

The overall landscape suggests that a variety of systems are now capable of being employed for sensing and metrology, with applications from precision time and frequency standards, to deployable field sensors and bio-imaging. The utility of exploiting quantum effects and control techniques for accessing new metrological capabilities is proven; using quantum logic methods on trapped ions, a new frequency standard has recently been developed in the US with measured fractional uncertainty more than two orders of magnitude better than the dominant contemporary technology. Similarly, techniques from quantum computing for phase estimation have been applied to a variety of precision measurements in proof-of-principle experiments, and may soon find application in demanding scientific and technological areas such as gravitational wave detection.

Quantum Computing

The field of Quantum Science has diversified significantly since the publication of Shor's algorithm set in motion the rapid development of what is now the field of quantum computation. Despite an expansion of applications and interests, the production of a functional and useful quantum computer remains a primary goal in the field of Quantum Science.

The field has been making huge strides not just in theory, but also in experimental implementations of quantum logic. The pace of experimental progress has been astounding with robust and useful qubits realized using trapped ions, neutral atoms, photons, spins in semiconductors, and superconducting circuits. Beginning with the first two-qubit logic gate in the 1990s using trapped ions, we've seen several experimental demonstrations of Shor's algorithm, demonstrations of Grover's search algorithm, simple implementations of quantum error correction, and most recently a fully programmable two-qubit quantum processor. Similarly, theoretical developments have accrued rapidly, with novel concepts such as topological quantum computing, subspace error correction codes, and measurement-based (one-way) computing making significant progress.

Open challenges remain, largely pertaining to the development of efficient and scalable quantum error correction protocols, the continued realization of high-precision quantum operations and the scale-up of quantum logic hardware. The trajectory is extremely positive, and at this time no fundamental roadblocks have been discovered suggesting that a realistic quantum computer is out of reach. But as mentioned above, the impacts of developments in the field are felt outside of the quantum computing community – quantum logic and algorithms are now being employed in precision metrology with interdisciplinary work likely to grow in the future.

Quantum Science in the 21st Century

Our newly discovered abilities to control and manipulate quantum coherent systems provide access to a host of physical phenomena that for decades were considered nothing more than mathematical oddities. Quantum Science permits us to use these basic phenomena underlying physical reality as a resource in the construction of new technologies, and the expansion of our knowledge of the world around us. The world will be a very different place at the end of the century, and Quantum Science will likely have had a lot to do with the changes we see.

Further Reading:

Quantum Technology: The Second Quantum Revolution, Jonathan P. Dowling, Gerard J. Milburn: http://arxiv.org/abs/quant-ph/0206091

Quantum Computation and Quantum Information, Michael A. Nielsen and Isaac L. Chuang. Cambridge University Press, 2000.

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Superconductivity in Geo-exploration

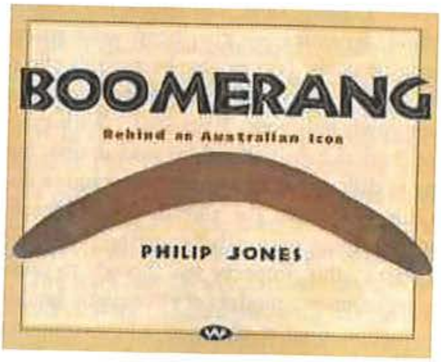
by John Macfarlane

It is impossible to expand here on all the projects that grew from the work on superconducting devices. The titles of some current or recent areas of activity include Quantum Engineering, Terahertz and Microwave, Oceanmag, Getmag, Magsafe and others. I shall mention only one project to which I made an early contribution, and which later evolved to be known as LANDTEM. Great credit for this outcome is due to the inspirational leadership of Graeme Sloggett, who succeeded me in 1991 as Project Leader; to Cathy Foley, who took over this role following Graeme's untimely death a few years later; and to Keith Leslie, the current Project Leader. Valuable experience in geomagnetic techniques was contributed by the CSIRO Division of Exploration and Mining. The CSIRO team with industrial partners has made significant progress in developing superconducting sensor systems for TEM (Transient Electro-Magnetic) prospecting. The TEM method is one of many mineral exploration techniques, and is widely used for the detection and delineation of highly conducting ore bodies such as nickel sulphides, silver and gold. In the "traditional" TEM methods, a square loop of wire about 100 x 100 m^2 is placed on the ground. When current is pulsed through it, eddy currents are induced in any electrically-conducting materials under the soil. These eddy currents generate transient magnetic fields, B, which in turn, induce transient secondary currents in a detecting coil located at a distance. In LANDTEM, the sensing of B-fields is accomplished by means of a radio-frequency (rf) SQUID. The history of LANDTEM is therefore closely linked to the history of SQUID development at NML, and can be traced back to the work initiated on Josephson-effect devices in 1969. The SQUID in the meantime has travelled a long way from its experimental beginnings in a cryogenics laboratory, and the crucial role played by superconductivity in a fully-operational geo-exploration technique was recognized by the award of the CSIRO Medal to the LANDTEM Team in 2007.

Reference missing from last issue:

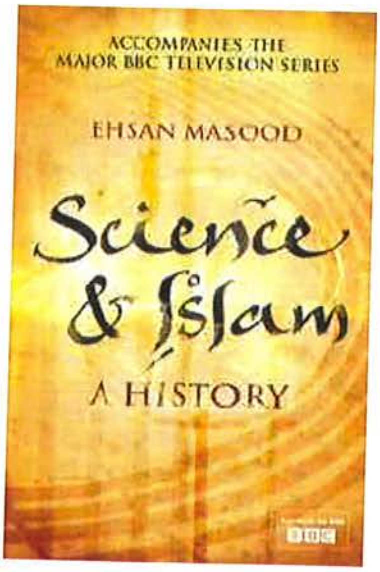
J. Du, A. D. Hellicar, L. Li, S. M. Hanham, J. C. Macfarlane, K. E. Leslie, N. Nikolic, C. P. Foley and K. J. Greene. Terahertz imaging at 77 K Supercond. Sci. Technol. 22 (2009) 114001 (6pp).

Book Reviews



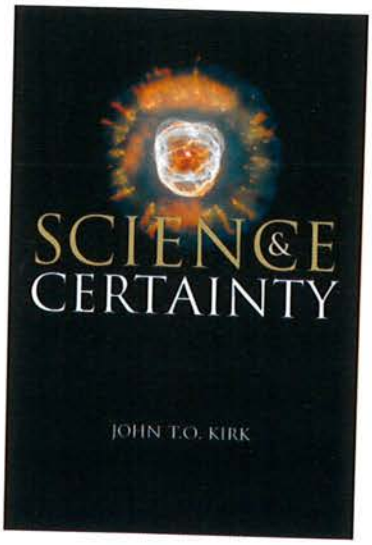
"Boomerang: Behind an Australian Icon" by Philip Jones, Wakefield Press.
ISBN: 1 86254 328 8

This book provides a description of the traditional making and uses of the boomerang, including in fighting, fishing, rituals and trade, decorating boomerangs, and the differences in appearance and usage across Australia. The book includes a good bibliography. The physics behind the flight of boomerangs is covered in four pages (here is a good article idea for our next Australian Physics).



"Science & Islam: A History" by Ehsan Masood, Allen & Unwin.
ISBN: 978 184831081 0

This book is an interesting compilation of a quite complex history of the extraordinary Islamic scientific revolution between 700 and 1400 AD. During this time scholars and researchers working from Samarkand in modern-day Uzbekistan to Spain advanced our knowledge of physics, chemistry, engineering, mathematics, medicine and philosophy to new frontiers. Science writer Ehsan Masood depicts the story of many scientists into a compelling narrative, on a journey through the Islamic empires of the middle ages, the cultural and religious circumstances that made this revolution possible, and its contribution to science in Western Europe. The book reports interesting debates between scientists, philosophers and theologians on the nature of physical reality and limits to human reason. In a well-conducted narrative the author explores the many reasons for the eventual decline of advanced science and learning in the Arabic-speaking world. The author included a must-read chapter on Astronomy. This book, associated with the BBC television series, should be essential reading for anyone interested in exploring new pespective's of science's history and its contribution to the making of the modern world.



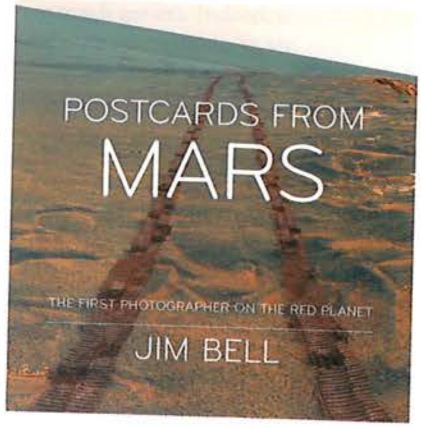
"Science & Certainty" by John Kirk, CSIRO Publishing.
ISBN: 978 064309391 1

How did the cosmos, and our own special part of it, come to be? How did life emerge and how did we arise within it? What can we say about the essential nature of the physical world? What can be said about the physical basis of consciousness? What can science tell or not tell us about the nature and origin of physical and biological reality?

Science and Certainty clears away the many misunderstandings surrounding these questions. The book addresses why certain areas of science cause concern to many people today – in particular, those which seem to have implications for the meaning of human existence, and for our significance on this planet and in the universe as a whole. It also examines the tension that can exist between scientific and religious belief systems.

Science and Certainty offers an account of what science does, in fact, ask us to believe about the most fundamental aspects of reality and, therefore, the implications of accepting the scientific world view. The author also includes a historical and philosophical background to a number of environmental issues and argues that it is only through science that we can hope to solve these problems.

This book will appeal to popular science readers, those with an interest in the environment and the implications of science for the meaning of human existence, as well as students of environmental studies, philosophy, ethics and theology.



"Postcards from Mars" by Jim Bell, CSIRO Publishing.
ISBN: 978 064309391 1

The most fantastic of all journeys — the Spirit and Opportunity mobile robot missions to the surface of Mars — produced hundred of thousands of astonishing photographs. While the images were made available on low-resolution computer screens as they were sent back across millions of space miles, no one until now has done the painstaking work of editing, cropping, and processing these massive (often larger than 100 megabytes) images.

The author is the payload element lead of the Panaroma Camera onboard both rovers. With his unique perspective, these photographs take us from the brave launches of these robots, to the alien landscape they discovered and the mysteries of the planet that they have helped to solve.

Over 150 lavish full-color-process prints bring the colors and textures of Mars to vivid life on the page. Four of the most impressive pictures are presented in their entirety as gatefold images providing a view of the surface of another planet unprecedented in its detail and clarity. Postcards from Mars is the perfect gift to give readers who have their feet on the ground and their eyes on the Sky.

Bell tells the story of preparing the spacecraft for launch and of the rovers' arrival on Mars in an unconventional tone, with just the right mix of detail and an interesting personal point of view.

cooling.

The system is based on a near-IR diode laser in the successful "pro design" (DL 100 / pro design, 1178nm), with a subsequent Raman fiber amplifier (RFA) and a resonant frequency doubling stage (SHG pro). The DL RFA SHG pro features a spectral linewidth below 1 MHz and 20 GHz modehop free tuning. For system operation, no water cooling and no external pump is required. The power scalable approach of the DL RFA SHG pro also offers solutions for other high power applications such as sodium LIDAR, medical therapy or super resolution microscopy. Customized systems with higher output powers up to 10 W are available on request. Wavelengths between 560 and 620 nm will soon be available as customized solutions.

SodiumStar > 20 Watt, single line @ 589 nm for laser guide stars

Based on the same technology as the DL RFA SHG pro, the SodiumStar is a narrow band, diffractionlimited laser light source with more than 20 Watt output power at the sodium resonance. The targeted application is adaptive optics control in ground-based telescopes. In modern large telescopes (mirror diameter > 7 m) adaptive optics is employed in order to correct the wavefront distortion induced by the Earth's atmosphere, yielding blurred images. As a reference object for adaptive optics so-called laser guide stars – laser-excited sodium atoms in the upper atmosphere – can be used. To this end, high power lasers exactly at the sodium resonance at 589 nm are required. The SodiumStar is a high power cw laser that employs resonant frequency doubling of a DL DFB with subsequent Raman fiber amplification. More than 20 W are attained at the Sodium wavelength of 589 nm, with a spectral width of 5 MHz.

FemtoFiber pro – the product family gets expanded

After the successful introduction of the FemtoFiber pro IR, NIR and SCIR models, TOPTICA is now doing the final step to also include the remaining system variants such as tunable visible (TVIS), tunable near-infrared (TNIR) and tunable ultra compressed pulse (UCP). Options like variable repetition rate (VAR) and a phase-locked loop Laser Repetition rate Control (LRC) by TOPTICA's well-established PLL-electronics are rounding up the FemtoFiber pro product family. The first and fastest of the new models, UCP, shows shortest pulses in the range down to 13 fs, the fastest one can get on the market from a turnkey SAM modelocked fiber laser system. The TVIS expands the supercontinuum generation (SCIR) by a tunable second harmonic generation and allows transferring femtosecond pulse generation into the visible wavelength range from 490 to 700 nm.

The TNIR variant finally adds a new feature to the FemtoFiber pro family. Opposite to the TVIS, it uses the high band continuum (>1560nm) for second harmonic generation. This continuum part is a solitonic pulse and therefore needs no pulse compression. The output wavelength can be tuned from 800 to 1100 nm. This variant was not available in the FFS product family.

For synchronization purposes, the FemtoFiber pro options VAR and LRC are established with a more than 200 kHz wide repetition rate modulation it allows to electronically synchronize two laser systems with lowest residual RMS jitter.

For more information please contact:
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Coherent

CEP for Legent Elite Amplifiers

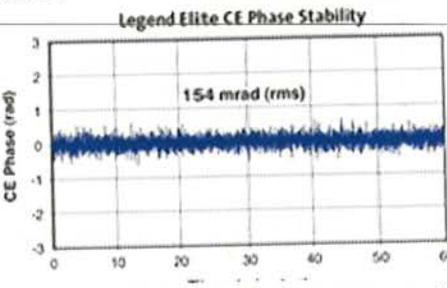
With the new Legend Elite CEP, Coherent Inc expands its family of Carrier-Envelope Phase stabilised ultrafast lasers.

The Legend Elite CEP amplifies the ultrafast pulses generated by the Micra CEP up to the millijoule level of energy required for applications such as High Harmonics Generation and attosecond science.

Legend Elite platform, this new ultrafast regenerative amplifier includes an active feedback control to lock the phase velocity of the oscillating light field to the group velocity of the phase envelope. Thus, for ultra short pulses consisting of only a few optical cycles, the peak of the oscillating electrical field can be maximised under the phase envelope.

At the heart of the Legend Elite CEP is a non-linear interferometer. An octave-spanning optical spectrum is generated by focusing a small part of the amplifier beam on a sapphire plate. The red end of this spectrum is frequency-doubled and collinearly combined with the blue end of this same broad spectrum. The resulting spectral interference fringes are measured by a spectrometer and custom software uses this signal to measure, stabilise and control the Carrier-Envelope Phase by making adjustments in the Legend amplifier.

The Legend Elite CEP is currently available with an average power of up to 4W, pulse energy up to 4mJ and pulse duration of less than 35fs. Additional configurations are under testing and will be released in the near future.



With the Verdi pumped Micra CEP and the Evolution pumped Legend Elite CEP, Coherent Inc is the first and only company

to offer a complete CEP-stabilised ultrafast amplifier system designed and built by a single manufacturer.

For more information please contact Paul Wardill (paulo.wardi@coherent.com.au) or Gerri Stewart (gerri.stewart@coherent.com.au).

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www.coherent.com.au

EMCCD camera now available with custom kinetics option

Kinetics mode is included as standard on all later model CCD and ICCD cameras from Princeton Instruments. Kinetics mode allows the vertical shifting of the camera to be directly controlled so that multiple images may be rapidly acquired and "stacked" on the CCD prior to readout.

The ProEM camera from Princeton Instruments is now available with a special masking option to further increase the camera's flexibility when operating in kinetics mode.

The new option includes an adjustable slit mask that allows the height of the kinetics sub-image to be varied in accordance with the experimental conditions. A further fixed mask is applied directly to the CCD, leaving the last two rows exposed for ultra high-speed kinetics acquisition.

For more information on the ProEM camera and on the new kinetics option please contact Paul Wardill (paul.wardill@coherent.com.au)

Warsash

Lightweight Benchtop Vibration Isolation

Warsash Scientific is pleased to announce a new lightweight benchtop vibration isolation system from Kinetic Systems, Inc. Specifically designed for portability, the ELpF can be easily repositioned on the benchtop, even with a load and in float. Its unique, self-contained design provides this without causing damage to the vibration isolators.

An economical alternative to heavyweight models, the Ergonomic Low-Profile-Format platform provides vibration isolation for sensitive devices. It features a load capacity of 100 or 300 lbs. in a lightweight, ergonomic system.

The platform has a low profile (only 3" high), uses a small tabletop (16" x 19" standard), and weighs 40 lbs., making it very portable. Ergonomic features include gauges tilted upward for easier viewing and recessed handles for easy carrying.

Designed for use in laboratories and Class 100 cleanrooms, the ELpF platform is ideal for supporting atomic force microscopes, microhardness testers, analytical balances, profilometers, and audio equipment.

Self-leveling and active-air isolation give the platform low natural frequencies (1.75 Hz vertical, 2.0 Hz horizontal) and typical isolation efficiencies of 95% (vertical) and 92% (horizontal) at 10 Hz.

Other tabletop sizes can be customized per specifications. The top, which can be ordered with or without mounting holes, can be aluminum plate, ferromagnetic stainless steel, plastic laminate, or anti-static laminate.

For more details on this or other vibration isolation equipment, contact sales@warsash.com.au

Real-Time Operating System for Systems Integration

PI (Physik Instrumente), the leading manufacturer of piezoceramic drives and positioning systems, offers a real-time module as an upgrade option for the host PC and also the connection of the GCS (PI General Command Set) software drivers. The module is based on Knoppix-Linux in conjunction with a pre-configured Linux real-time extension (RTAI).

The use of real-time operating systems on the host PC allows it to communicate with other system components, e.g. a vision system, without time delays with discrete temporal behavior and high system clock rate.

A library which is 100% compatible with all other PI GCS libraries is used for the communication with the real-time system. All PI GCS host software available for Linux can be run on this system.

Real-Time Operating System for Systems Integration by Physik Instrumente

The real-time system running in the real-time kernel can be used to integrate PI interfaces and additional data acquisition boards for control. Open functions to enable you to implement your own control algorithms are provided. Data, such as positions and voltages, is recorded in real time, and pre-defined tables, with positions, for example, are output in real time to the PI interface and to additional data acquisition boards.

You can program your own real-time functions in C/C++, MATLAB/SIMULINK and SCILAB.

The system includes a PI GCS server, which allows the system to be operated as a blackbox using TCP/IP, via a Windows computer, for example.

Product News continued over page...

The system can be installed on a PC or booted directly as a live version from the data carrier. A free demo version with restricted functionality is available.

For more information on the real time operating software or other PI positioning equipment, contact sales@warsash.com.au

E-618: 3.2 kW Peak Power for New Piezo Amplifier
Available from Warsash Scientific is the new PI

(Physik Instrumente) E-618 high power amplifier for ultra-high dynamics operation of PICMA® piezo actuators.

The amplifier can output and sink a peak current of 20A in the voltage range between -30 and +130V. The high bandwidth of over 15kHz makes it possible to exploit the dynamics of the PICMA® actuators. This type of performance is required in active vibration cancellation and fast valve actuation applications.
The E-618 also comes with a temperature sensor input to shut down the amplifier if the maximum allowed temperature of the piezo ceramics has been exceeded. This is a valuable safety feature given the extremely high power output.

The E-618 is available in several open-loop and closed-loop versions with analogue and digital interfaces.

For more information on these and the range of other PI products, contact sales@warsash.com.au

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New Sensors Improve Precision of S-340 Tip/Tilt Mirror
Warsash Scientific is pleased to announce the release of the new S-340 piezo tip/tilt mirror platform from PI (Physik Instrumente), equipped with new high-resolution strain gauge sensors.

The S-340 now achieves a resolution of 20nrad at angles of 2mrad about both orthogonal axes.

This large mirror platform is used for optics with diameters of up to 100 mm (4 inches) and achieves a resonant frequency of 900Hz for a mirror of 50 mm diameter.

The S-340 can be operated by the new, low-cost E-616 controller. Together, they form a compact, high-performance solution for beam control and image stabilization as employed in astronomy, laser machining or optical metrology, for example.

New Sensors Improve Precision of S-340 Tip/Tilt Mirror

For more information on the S-340 Tip/Tilt Mirror platform or other Positioning equipment from PI, contact sales@warsash.com.au

2010 AIP Congress

'Living Physics' in Melbourne: 2010 Australian Institute of Physics Congress

This year marks the 50^{th} anniversary of the discovery of the laser. It is timely that in 2010 the Australian Institute of Physics Congress, 'Living Physics', brings together the Australian Conference on Optical Fibre Technology and the annual meeting of the Australian Optical Society to celebrate 'Laserfest'. In addition to our plenary speakers, Professor Margaret Murnane, an expert on ultrafast laser science, and Professor David Payne of the University of Southampton, one of the pioneers of the optical fibre laser, there will be an extended session dedicated to looking at the past, present and future of this ubiquitous invention that has transformed so many aspects of our lives.

The AIP Congress presents a unique opportunity for the Australian physics community to come together, discuss cutting-edge research, share breakthrough ideas and showcase our achievements to the nation. Other plenary speakers extend across the breadth of physics: Bruce Allen, Director of the Max Planck Institute for Gravitational Physics (the Albert Einstein Institute) who also directs the Einstein@ Home project, Tim Fuller-Rowell of the University of Colorado, Boulder and the NOAA Space Weather Prediction Center, David Karoly, an internationally-recognised expert in climate change and climate variability, Jeremy Mould, winner of the 2009 Gruber Prize for Cosmology, Mike Norman, head of the Condensed Matter Theory Group at Argonne National Laboratory and Rolf-Dieter Heuer, Director-General of CERN.

Catered poster sessions on Monday and Wednesday evening will provide a relaxed opportunity to discuss research following lively sessions of contributed and invited talks. Following the poster session on Wednesday evening, Professor Jocelyn Bell-Burnell will present one of her renowned public lectures. The Congress will also include a Women in Physics forum viewing the 'Generational Landscape'. A special short course in Nanofabrication will be held and is free to delegates – an excellent way to get an introduction to a technology that may yet become as pervasive as the laser. Please visit the Congress website www.aip2010.org.au for more information.

The Congress will be held in Melbourne's stunning new convention centre sited on the banks of the Yarra River close to the CBD. The dinner on Tuesday evening will provide an opportunity to relax with colleagues in the magnificent, heritage-listed Plaza Ballroom, one of Melbourne's hidden treasures. While the setting will be grand the success of the event depends on you and your attendance and contributions to the program. We invite you to join us in this significant celebration of Australian physics in Melbourne in December.

Ann Roberts and Andrew Peele, Congress Co-Chairs

Conferences

August 2 - 10
Quo Vadis Bose-Einstein-Condensation?
Dresden, Germany
http://www.mpipks-dresden.mpg.de/pages/veranstaltungen/frames_veranst_en.html

August 23 - 27
20th International Congress on Acoustics (ICA 2010)
Sydney, New South Wales
http://www.ica2010sydney.org/

August 30 - September 3
9th Quark Confinement and Hadron Spectrum
Madrid, Spain
http://teorica.fis.ucm.es/Confinement

September 13 - 18
4th International Congress on Advanced Electromagnetic Materials in Microwaves and Optics
Karlsruhe, Germany
http://congress2010.metamorphose-vi.org/

November 10 - 12
International Conference on Earth and Space Sciences and Engineering (ICESSE 2010)
Sydney, New South Wales
http://www.waset.org/conferences/2010/sydney/icesse/index.php

November 14 - 18
55th Conference on Magnetism and Magnetic Materials
Atlanta, USA
http://www.magnetism.org

November 15-19
Broadband for Society Summit
Hobart, TAS
http://www.zxcvbn.org

December 6 - 10
2010 AIP Congress
Melbourne, Victoria
http://www.aip2010.org.au/

December 13 - 16
International Conference on Nano Materials and Nanotechnology (NANO 2010)
Nammakkal, India
http://ksrct.ac.in

December 16 - 17
3rd International Conference on Science & Technology : Applications in Industry and Education (ICSTIE 2010)
Penang, Malaysia
http://www.icstie.com

April 4 - 8, 2011
Greenhouse 2011
Cairns Convention Centre, Queensland
http://www.greenhouse2011.com

June 28 - July, 2011
IUGG Earth on the Edge: Science for a Sustainable Planet
Melbourne, Victoria
http://www.iugg2011.com