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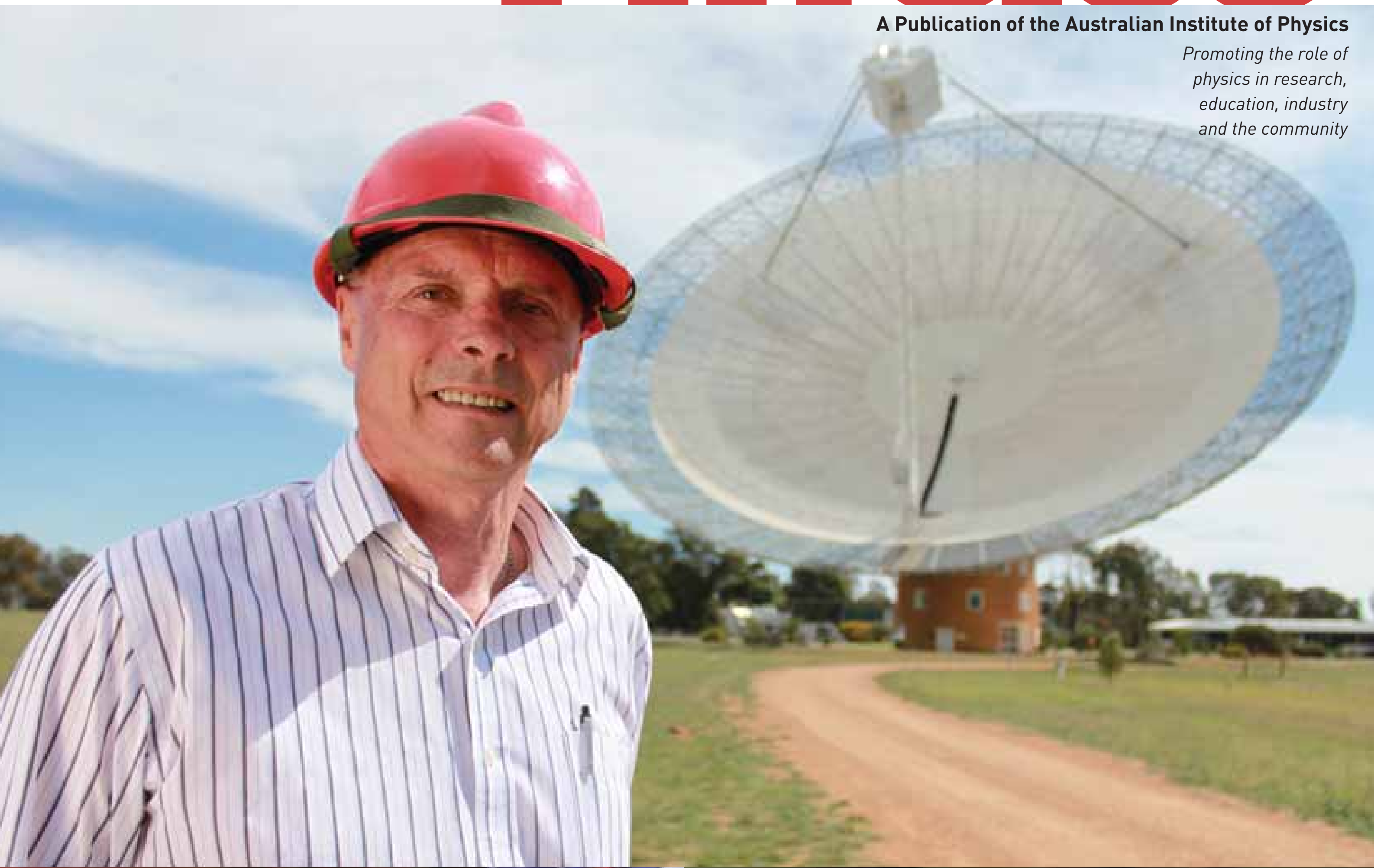
Promoting the role of physics in research, education, industry and the community



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Australian Physics
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Contents

Volume 46 Number 6

Features

Regulars

Write an article for Australian Physics

We are looking for articles covering all aspects of physics in Australia. Perhaps your area of Physics is not well known, is unusual in some way, or you work at a smaller univeristy; perhaps your career has developed in uncoventional ways; if so, why not write an article for Australian Physics?

For more information contact the editor-in-chief Dr M. L. Duldig at (Marc.Duldig@aad.gov.au).

Cover Image

John O'Sullivan (top), Amanda Barnard (left) and Len Altman (right) are three of the winners of the 2009 Prime Minister's Prize for Science.

Read their full stories on page 168.
Image credits: Bearcage Productions

Submission deadline for the January/February 2010 issue is 10 February

Contributions should be sent to
Dr Marc Duldig
Marc.Duldig@aad.gov.au

Submission Guidelines
Articles for submission to Australian Physics should be sent in electronic format. 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 length, space requirements and editorial content.

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Editorial

At the end of each year most academics find it difficult to focus on any matter that is not urgent; however, the end of the year is also the time we get to announce and publish the recipients of a few of the AIP honours: The Outstanding Service to Physics Award to John O'Connor; the 2010 Bragg Gold Medal for Excellence in Physics to Clancy James; the 2009 Walter Boas Medal to Victor Flambaum; and the Thomas Laby Medal to Dilani Kahawala. (Full stories and citations can be found in the Branch News and Awards section on page 162.)

In addition, we also have the pleasure to profile three winners of 2009 Prime Minister's Prizes for Science, each of whom possesses a physics background. (Their full stories, along with the names of the other recipients, begin on page 168.)

Normally I don't illustrate our cover with people, it can seem a little grandiose, but sometimes it's worth doing something different. In this case, given the significance of their contribution to the nation, to physics and to teaching I thought it merited your full attention.

By the time you read this issue the new year will be ready to begin, and we can look forward to another round of excellence within one short year.
John Daicopoulos

Letter

Dear Sir,

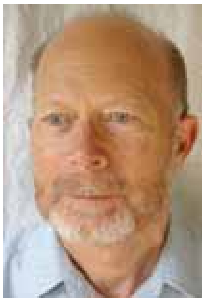
I read with amazement the President's Column in Sept/Oct 2009 Australian Physics, on the relative merits of the arguments for and against climate change being caused by human induced changes in the carbon dioxide (CO_2) levels in Earth's atmosphere. In particular I note the condemnation of Internet websites that are often quoted as the origins of the anti CO_2 caused climate change debate. There is a large amount of information maintained by reputable government organizations such as NASA and outstanding universities pointing out some obvious and interesting features.

A quick Internet search and some easy calculations soon establish that Earth's atmosphere contains approximately 1.8 trillion tons of CO_2, while Mars' atmosphere contains approximately 36 trillion tons of CO_2. With 20 times as much CO_2 in its atmosphere, Mars is several degrees Celsius cooler than it otherwise should be, all other factors considered. Another feature evident is that all fossil fuels originated from CO_2 in the atmosphere. Photosynthesis captured it and geological effects converted to fossil fuels. Scientist have not pointed out that period in Earth's history when that CO_2 caused the disastrous problems often predicted in scientifically reviewed papers. Also, far from being a pollutant, CO_2 is essential for all terrestrial and surface ocean life.

There is very strong evidence that CO_2 is not responsible for planetary warming and higher amounts of it in Earth's atmosphere will not cause the doomsday scenarios pointed out in some refereed publications. Large and increasing numbers of scientists and the general public are sceptical about the concept. Based on the above and other observations, there is very little physics justification for the concept of human generated CO_2 having any effect upon the temperature of planet Earth. The time for scientific opinions expressed by those who wish to call themselves experts should be long gone. It is time for facts to be presented, and not just from one side. This is one topic in which physicists profess to have some knowledge and surely it should be debated in Australian Physics based upon facts and not opinion.

There is no doubt we will eventually need to revert to renewable energy. It should be done in a controlled manner for the right scientific reasons. Unlike most environmentalists, I am "putting my money where my mouth is" and self funding projects that have the potential to make a difference to the environment, including one with the possibility for capturing and recycling CO_2 in a sustainable manner.
Vivian Robinson

President's column



An important function of a professional society like the Australian Institute of Physics is to encourage and recognise excellence in the discipline via awards, prizes and scholarships. The Medals/Prizes section of our website lists seven such awards. One of the most pleasant and rewarding activities for the President is announcing and presenting the AIP's awards. Recently, at a function at the ANU organised by the ACT Branch, I presented the 2009 Bragg Gold Medal for Excellence in Physics for the best PhD thesis by a student from an Australian University to Christian Rosberg, and an AIP Award for Outstanding Service to Physics in Australia to Professor Hans Bachor. More recently, I presented an AIP Award for Outstanding Service to Physics in Australia to Professor John O'Connor at a ceremony at University of Newcastle. If you are not familiar with our awards, please look at the information on the website – you may see an opportunity to nominate someone.

Another important function for a professional society is to lead celebration of important events in the history of the discipline. The International Year of Physics in 2005, which recognised Einstein's *annus mirabilis* is an example. This year, the International Year of Astronomy, the AIP used its branch structure to support a national program of talks organised by our cognate society, the Astronomical Society of Australia.

In 2010 we have the anniversary of a major development in Physics: the 50th anniversary of first successful operation of a laser by Theodore Maiman at Hughes Aircraft Company. Although described for some time as 'a solution seeking a problem' we now appreciate the many advances in technology that the laser spawned, and its role in advances in other areas of Physics and other sciences. In particular it produced a revolution in atomic spectroscopy that made possible Bose-Einstein condensation and the current developments in atoms optics. In the latter area we are probably at a stage not unlike that of the laser 50 years ago! The AIP and our cognate society the Australian Optical Society, will both seek ways to recognise the laser's anniversary. This could include an issue of *Australian Physics* devoted to the laser. If you have ideas for a suitable article, perhaps something about the early days of the uses of lasers in Australia, the development of lasers and their applications in Australia, or even brief anecdotes, please contact me, or the Editor-in-Chief, Dr Marc Duldig.

Over the last 12 months the executive has needed to devote an undue amount of time to management issues. For several years our membership and financial services have been provided by Materials Australia. When Materials Australia introduced online membership in late 2009 we encountered ongoing problems, and a certain fraction of members would have been very frustrated by some of the problems that arose. In part as a result of this, but also due to an increasingly problematic relationship, the Executive canvassed alternatives and in late November we engaged WaldronSmith Management to provide membership and financial services. By coincidence this is the same organization that won the contract for organising the AIP Congress in Melbourne in December 2010. We are confident that the new arrangements will enable us to devote our efforts to more important policy and membership matters rather than just managing the organisation. Our tasks in 2010 will include a membership drive and redevelopment of our website to better provide services for members and the wider Physics community.

On behalf of the Executive, I wish all members a peaceful holiday season and fruitful 2010.

President Brian James replies to Vivian Robinson:

There is an enormous amount of material in the scientific literature on the physical processes relevant to climate change. While different people familiar with this might reach different conclusions as to the significance of the steady increase in CO_2 concentration due to human activity, there is a clear scientific consensus. I would be very surprised if many members read my comments 'with amazement'.

Branch News and Awards

Outstanding Service to Physics in Australia Award

On Tuesday 1 December, the President of the Australian Institute of Physics, A/Prof Brian James, presented the award for Outstanding Service to Physics in Australia to Professor John O'Connor, Head of the School of Mathematical and Physical Sciences, University of Newcastle. The award is made in recognition of Professor O'Connor's service to Physics, covering research, teaching, outreach and professional activities.

His research interests are in the field of materials science, with a particular emphasis on surface physics. He is a leader in this field in Australia, and is recognised internationally for his contribution to the field. In 1993 he was a member of the inaugural editorial board of the journal Surface Review and Letters. In recent years his knowledge and guidance have been invaluable to the Australian ITER Forum, a group of around 100 Australian scientists and engineers seeking involvement in ITER, the international fusion energy project currently getting under way.

AIP president Brian James presenting an award for Outstanding Service to Physics in Australia to Professor John O'Connor at the University of Newcastle.

From 1995-2001 Prof O'Connor was Australian Councillor to the International Union of Vacuum Science, Technology and Applications (IUVSTA). He has also served IUVSTA as secretary of its Surface Science Executive Committee and as a trustee of the Welch Foundation, which carries out an international scholarship award function of IUVSTA.
Prof O'Connor has supervised more than 50 higher degree students and in 1999 received, jointly with R.J. MacDonald, B.V. King and P.C. Dastoor, a University of Newcastle Teaching Excellence Award for excellence in postgraduate teaching.

In 2003 he was awarded, jointly with A. Page and R. Nelson, the Sir William Hudson Award for outstanding engineering excellence for the Science and Engineering Challenge program, which is an outreach program conducted nationally to inspire school students to study science and engineering at a senior level. In 2009, the Science and Engineering Challenge involved almost 20,000 students from over 600 schools across Australia. He has had regular radio shows for the last 10 years, is a foundation member of the Australian Science Communicators and worked on a PMSEIC working party on Science Outreach. In recognition of this long term commitment to science and engineering outreach he was elected as a Fellow of the Academy of Technological Sciences and Engineering in 2009.

Prof O'Connor is a fellow of the Australian Institute of Physics, and was its president 2001-3. He is a Fellow of the Institute of Physics (UK) and he was Physical Sciences representative on the Board of the Federation of Science and Technology Societies (FASTS) 2000-2 and secretary of FASTS 2001-4. Over the periods 2000-2 and 2007–11 he served as a member of the National Committee for Physics, which is a committee of the Australian Academy of Science
In recognition of his outstanding contributions to many aspects of Physics in Australia, the Australian Institute of Physics is pleased to award to Professor John O'Connor an award for Outstanding Service to Physics in Australia.

2010 Bragg Gold Medal for Excellence in Physics

The winner of the 2010 Bragg Gold Medal for Excellence in Physics, awarded for the best PhD thesis by a student from an Australian University, is Clancy James. Clancy completed his thesis, entitled Ultra-High Energy Particle Detection with the Lunar Cherenkov Technique at the University of Adelaide, under the supervision of Associate Professor Ray Protheroe (School of Chemistry and Physics, University of Adelaide) and Professor Ron Ekers (Australia Telescope National Facility). He is currently working at Radboud University, Nijmegen, the Netherlands, having received a Rubicon Fellowship. It is hoped to make the award during an observing trip to Australia in 2010.

Clancy James' bio:

Enrolled at the University of Adelaide in 2001, completing his bachelors in 2004 and honours degree – in astrophysics - in 2005, jointly receiving the H.S. Green Prize for best theoretical physics honours.

He began his PhD project in 2006, supervised by Ray Protheroe (U. Adelaide) and co-supervised by Ron Ekers (ATNF CSIRO). The project was the LUNASKA – Lunar Ultra-high energy (UHE) Neutrino Astrophysics with the Square Kilometre Array (SKA).

The initial scope of the PhD was to develop a simulation to model and optimise the detection process. The first important result to come was that the most cited experiment of this type had over-estimated their sensitivity by about an order of magnitude; the next, that whereas the pulses were expected

to be very sharp and clean, the sub-class of interactions which should lead to the most powerful signals would produce a signal that looked much like anthropogenic RFI to a detector.

Other PhD work involves experiments at the Australia Telescope Compact Array (ATCA) looking for lunar pulses. Simulations have shown that we could target potential sources of UHE particles via a careful choice of observation dates and observing configuration. No pulse signatures appeared in the data, although 'test observations' had eclipsed the sensitivity of all previous attempts. As a result, the team has inadvertently devised an extremely sensitive method for identifying local interference sources. For this work he received the 2009 Harold Woolhouse Prize for best PhD thesis in the Faculty of Sciences at the University of Adelaide.

Victoria

2009 Walter Boas Medal

Professor Victor Flambaum, FAA and Chair of Theoretical Physics in the School of Physics, University of New South Wales, has been awarded the 2009 Walter Boas Medal by the Australian Institute of Physics.

The medal recognises his pioneering research in the areas of space-time variation of the fundamental constants, the violation of fundamental symmetries and tests of unification theories of elementary particles.

Prof. Flambaum was presented with the medal by past AIP president Professor David Jamieson at the November meeting of the Victorian Branch. The topic of his Boas Medal Lecture was 'Parity and time reversal violation in atoms and nuclei and the search for physics beyond the Standard Model'.

The talk was divided into three parts. The first was a discussion of recent measurements of the caesium weak charge that have indicated a possible deviation from the predictions of the Standard Model. The UNSW group has performed new calculations of parity violation in caesium which have led to a significant reduction in the theoretical errors, and which are pointing the way to the possibility of 'new physics' beyond the Standard Model.

Professor Victor Flambaum (left) with Professor John Boas at the presentation of the 2009 Walter Boas Medal at the School of Physics, University of Melbourne

Victor also discussed how atomic and molecular experiments can be used to detect the nuclear 'anapole' moment, that is, the magnetic multipole which violates the fundamental symmetries of parity and charge conjugation.

A third research area by the group at UNSW consists of calculations of atomic electric dipole moments (EDM), which also present the possibility of searching for physics beyond the Standard Model. Victor explained the different mechanisms generating atomic EDM and presented results of recent measurements testing models of CP violation. These new experiments will provide a crucial test of various models such as supersymmetry.

Thomas Laby Medal

The September meeting of the Victorian branch began with the presentation of the Thomas Laby Medal to the father of Ms Dilani Kahawala (Monash University). Dilani was unable to attend the presentation as she is currently undertaking graduate studies in the US. Her thesis was entitled 'The Supersymmetry Inverse Problem' and the Laby medal panel noted that the standard of work and achievement was outstanding for an honours project.

The presentation was followed by a talk by Marc Duldig, a Senior Principal Research Scientist with the Australian Antarctic Division in Hobart. Marc manages the atmospheric component of the Division's climate program, as well as the cosmic ray laboratories.

In his talk 'Particle Astronomy - the Second Window', Marc explained how traditional astronomy relies on light to bring information to the observer. This covers the whole electromagnetic spectrum from radio and infrared through the visible night sky to ultra-violet, X-rays and gamma rays. However, there is another spectrum available to astronomers – the cosmic ray spectrum. Cosmic rays are particles travelling close to the speed of light and they carry different kinds of information about their sources and where they have been on their travels to Earth.

Marc spoke about the history of cosmic ray research that has led to several Nobel Prizes in physics. Cosmic rays are also used for practical purposes such as sample dating and climate change research. Marc's talk was sponsored by the AIP as part of the activities celebrating the International Year of Astronomy.

Marc Duldig with Victorian branch chair Nicoleta Dragomir. Marc is currently Vice President of the Australian Institute of Physics and is a long-standing Secretary of the Astronomical Society of Australia.

New South Wales

The September meeting of the branch was held at the University of Sydney and featured a public talk by Michael Box. Michael is currently working as an Associate Professor in Physics at the UNSW and his research comprises on particle scattering theory, remote sensing inversion theory, radiative transfer, aerosol optical properties and effects. Michael's work covers all aspects of atmospheric aerosols (suspended particles) and their environmental impacts and has published many papers in these areas.

His group is currently investigating the distribution of aerosols in Sydney, and especially any chemical or physical variations. The work of his group is directed at studying aerosol amounts and type from space, and also at computing the climatic impact of these aerosols which his talk was based on Atmospheric Aerosols: Physics, Chemistry and Climatic Impacts

Michael's group has been investigating the physics and chemistry of mineral dust aerosols from Australia's arid interior. They have undertaken 3 field campaigns, collecting a number of sets of size-resolved samples. These have been subjected to Ion Beam Analysis to determine their metal content, Ion Chromatography for soluble ion content (including organic acids), and QEMSCAN, a revolutionary new CSIRO-developed mineralogy tool for studying individual particles. They also collected samples during the recent Sydney dust storm, which should lead to invaluable intercomparisons.

The October meeting featured a public talk by Iver Cairns. Prof. Cairns is Professor in Space Physics at the University of Sydney. He is a world expert in the theory and observation of waves and radio emissions in space, focusing on the plasma physics, with about 200 refereed publications in books and journals.

Australia has significant expertise and history in space science. It was the fourth nation to launch a spacecraft into orbit from its own territory, in 1967. Its second satellite followed 35 years later, with FedSat launched in December 2002. Today, as it has for the last 50 years, Australia has experts in many areas of space science and technology. But until very recently it has had no coordinated national space effort or dedicated funding for space research.

In an effort to remedy this situation and to organize the space science community, the National Committee for Space Science (Australian Academy of Science) started to develop the first Australian Decadal Plan for Space Science in 2005. The Draft Decadal Plan was released for public comment in February 2008. It predated and partly motivated the 2008 Cutler Report "Venturous Australia", the 2008 Senate Report "Lost in Space" and the Government's major investments into Space announced in the 2009 Budget.

Indeed 2009 is a historic year for space research in Australia. This year the Australian Government made "space and astronomy" one of three research areas in the Super Science Initiative. It also created the $40 M Australian Space Research Program and the $9 M Space Policy Unit. Government now recognizes the importance of Space, both in the civil domain but also in the Defence White Paper. This is a fundamental change in perspective.

Prof. Cairns's talk focused on the revised version of the Plan, submitted to the Academy of Science in October 2009 for endorsement, which describes the vision of the Australian space science community for the next 10 years. The motto is "Build Australia a long term, productive presence in Space via world-leading innovative space science and technology, strong education and outreach, and international collaborations."

The NSW Branch held its first annual Postgraduate Awards Day at the University of Sydney. Each New South Wales university was invited to nominate one student to compete for the $500 prize and Postgraduate medal on that day. Students nominated for the awards were also invited as guests for the NSW AIP Branch annual dinner that followed the presentations. These awards have been created to encourage excellence in postgraduate work, and all nominees who participate in the Postgraduate Awards Day also received a special certificate recognising the nominee's high standing.

The nominated speakers for 2009 were:

- Julian King, University of New South Wales: Probing the Fundamental Constants of Nature with Quasar Spectroscopy;
- Steven Lade, Australian National University: Directed Transport without Net Bias in Physics and Biology;
- Eduardo Granados, Macquarie University: Ultrafast Lasers Go Ultraviolet;
- Felix Lawrence, University of Sydney: Impedance and Photonic Crystals;
- Martin Blaber, University of Technology Sydney: Determining Ideal Plasmonic Materials
- Stuart Hargreaves, University of Wollongong :THz Emission Mechanisms in Semiconductor.

The winner of the AIP Postgraduate Presentation for 2009 was awarded to Felix Lawrence. Felix received the 2009 Crystal Postgraduate figurine and a $500 cheque from the AIP. The AIP congratulates Felix on this wonderful achievement. The five runner's up received a small AIP medal and a special certificate recognising the nominee's high standing.

This event was proudly sponsored by the AIP and the Astronomical Society of Australian as the International Year of Astronomy, The CSIRO and the Campus Review.

Dr Frederick Osman

From left to right, Dr Tony Farmer (CSIRO), Mr Felix Lawrence (USYD) and Dr Fred Osman (AIP Branch Chair)

News

CSIRO innovator wins NSW Telstra Business Women award

Dr Cathy Foley from CSIRO's Materials Science and Engineering Division was awarded the NSW Nokia Business Innovation Award in the Telstra Business Women's Awards.

Dr Foley leads CSIRO's work in materials physics, instrumentation, engineering and the Advanced Materials Research Platform. She is also renowned as one of the country's top applied physicists.

The prestigious award is primarily for Dr Foley's invention of the method to make a highly sensitive magnetic field sensor using a high-temperature superconductor. This sensor is the basis of the mineral exploration tool, LANDTEM™, for which she led the initial development and commercialisation in collaboration with BHP Billiton and then the Canadian mining company, Falconbridge. LANDTEM has since been licensed to an Australian start-up company, Outer-Rim Development and has ultimately helped to unearth around $6 billion of new mines worldwide.

Mineral deposits such as nickel, gold and silver are buried deep below the surface are often hard to find because they are too 'electrically conducting' or, in some cases in Australia, buried beneath ancient conducting soils making them impossible to detect using conventional magnetic sensors.

LANDTEM is a portable exploration tool that uses highly sensitive magnetic sensors known as SQUIDs (Superconducting Quantum Interference Devices) to differentiate the ore from other conductive material.

As well as being an internationally recognised leader in Superconducting Electronics, Dr Foley is also very active in promoting science and women in science. She was the first woman to be elected President of the Australian Institute of Physics (AIP) in 2007.

"This award is an enormous acknowledgement of the progress of women in science and physics in particular," Dr Foley said.

"When I entered this career, there were few women physicists – less than 5 per cent – and virtually none in senior roles. I will use this award to leverage the funding of women in science initiatives through the AIP."

Dr Foley is also the rapid communications editor and board member of the UK's Institute of Physics' journal, Superconductor Science and Technology, and President Elect (from November 2009) of the Federation of Australian Scientific and Technological Societies (FASTS) which represents 60,000 scientists and technologists in Australia.
CSIRO

Barry Inglis elected President of CIPM

Barry Inglis, recently CEO of the National Measurement Institute and former member of CSIRO Industrial Physics, has been elected as the next President of the International Committee of Weights and Measures (CIPM), probably the most prestigious position in world metrology. Barry will take up his position in October 2010 on the expiry of the term of the present President, Prof Ernst Goebel of PTB.

Barry will be the first Australian ever to achieve this honour since the Treaty of the Metre was signed in 1875. In that time there have been 14 individuals appointed to the position, of only eight different nationalities. Members of the CIPM have included such scientific luminaries as de Broglie, Mendeleev, Michelson and Lounasmaa.
CIPM

Large Hadron Collider

Well, they've done it: at 2028 GMT, 29 November 2009 the Large Hadron Collider officially became the most powerful particle accelerator ever built by humans. One of the proton beams in the LHC was powered up to 1.05 teraelectron volts (TeV) at that time, and three hours later both of the beams were powered to 1.18 TeV. This breaks the previous record held by the Fermilab accelerator in Chicago, which has held the record of .98 TeV since 2001.

Despite the initial problems that the largest scientific instrument ever built had this past year, things seem to be progressing smoothly. The proton-proton beams were collided for the first time at 0.9997 times the speed of light.

Image credit: CERN

Each beam will be powered up to 3.5 TeV to smash protons in order to re-create the conditions that existed near the time of the Big Bang, and help physicists understand the fundamental nature of matter. The 7 TeV goal should be reached by the end of December, and the first collisions at the amazing energies of the LHC will occur in early 2010.

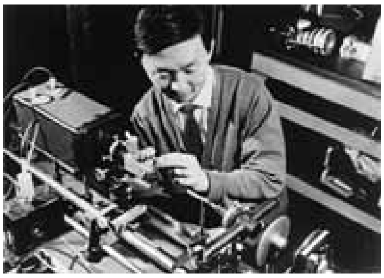
Director-General of CERN Rolf Heuer said the recent progress has been fantastic. "However, we are continuing to take it step by step, and there is still a lot to do before we start physics in 2010," he said. "I'm keeping my champagne on ice until then."

The LHC, is a 27 km (17 mile) long circular tunnel composed of super-cooled, superconducting magnets that runs underneath the town of Geneva, Switzerland. By colliding protons together at such energetic speeds, some fundamental questions about what matter is made of, and what the conditions were like around the earliest times of our Universe may be answered.
CERN

Nobel Prize in Physics

This year's Nobel Prize in Physics is awarded for two scientific achievements that have helped to shape the foundations of today's networked societies. They have created many practical innovations for everyday life and provided new tools for scientific exploration.

In 1966, Charles K. Kao made a discovery that led to a breakthrough in fiber optics. He carefully calculated how to transmit light over long distances via optical glass fibers. With a fiber of purest glass it would be possible to transmit light signals over 100 kilometers, compared to only 20



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meters for the fibers available in the 1960s. Kao's enthusiasm inspired other researchers to share his vision of the future potential of fiber optics. The first ultrapure fiber was successfully fabricated just four years later, in 1970.

Today optical fibers make up the circulatory system that nourishes our communication society. These low-loss glass fibers facilitate global broadband communication such as the Internet.

Light flows in thin threads of glass, and it carries almost all of the telephony and data traffic in each and every direction. Text, music, images and video can be transferred around the globe in a split second.

Photo: Alcatel-Lucent/Bell Labs

If we were to unravel all of the glass fibers that wind around the globe, we would get a single thread over one billion kilometers long – which is enough to encircle the globe more than 25 000 times – and is increasing by thousands of kilometers every hour.

A large share of the traffic is made up of digital images, which constitute the second part of the award. In 1969 Willard S. Boyle and George E. Smith invented the first successful imaging technology using a digital sensor, a CCD (Charge-Coupled Device).

The CCD technology makes use of the photoelectric effect, as theorized by Albert Einstein and for which he was awarded the 1921 year's Nobel Prize. By this effect, light is transformed into electric signals. The challenge when designing an image sensor was to gather and read out the signals in a large number of image points, pixels, in a short time.

The CCD is the digital camera's electronic eye. It revolutionized photography, as light could now be captured electronically instead of on film. The digital form facilitates the processing and distribution of these images. CCD technology is also used in many medical applications, e.g. imaging the inside of the human body, both for diagnostics and for microsurgery.

Digital photography has become an irreplaceable tool in many fields of research. The CCD has provided new possibilities to visualize the previously unseen. It has given us crystal clear images of distant places in our universe as well as the depths of the oceans.

Nobel Committee

Lazy Rocks

2009 AIP Physics Photo Contest
Winner: Kendall Phillips, Year 10
Title: 'Lazy Rocks'
School: Melbourne Girls' College
Teacher: Chris Jurgens

In Isaac Newton's First Law of Motion, he said, "When an object is in motion, it wants to stay in motion and when an object is at rest, it wants to stay at rest until acted upon by some outside source". For some people this is a lot to remember so Newton's first law of motion is sometimes called the 'Law of Laziness'. Things like to keep doing what they are already doing, so if something is not moving, it wants to stay not moving, and if it is already moving, it wants to keep moving until acted upon by another force.

In my photo, Newton's first law of motion is shown. I took the photo just as the rocks were being 'lazy'. As you can see by the red line, the rocks have stayed in the exact same line as where the trampoline used to be, even though it's not there anymore.

The Scientists in Schools Programme: A physics perspective

Dr. Jim Peacock,
Chair, CSIRO OCE Science Team

There can be nothing more important to the future of Australia than educating our children. Take, for instance, the winner of this year's Nobel Prize in Physiology or Medicine, Australian Elizabeth Blackburn. Was it evident when Elizabeth was a child that she would be the 2009 Nobel laureate? Or did teachers, scientists and mentors nurture and excite her love of science and encourage in her an investigative approach to learning?

This is the aim of our Scientists in Schools program, an initiative from my term as Chief Scientist, and managed by CSIRO Education with funding from the Australian Government Department of Education, Employment and Workplace Relations. Through Scientists in Schools, individual teachers from primary and secondary schools are matched in long-term, professional partnerships with scientists to provide the teacher with access to contemporary, day-to-day science and technology. The teacher and scientist are free to develop their partnership in a way that suits both parties dependent on their needs, time commitments and energy.

In many cases, this takes the form of visits to the school by the scientist to assist with a class project, to talk about their career progression or simply to dispel stereotypic perceptions about what a scientist looks like. In other partnerships, the teacher utilises the scientist as an email expert to keep them up to date with the latest advances in their field or to answer more complex scientific questions that the students may have.

One very successful partnership is between CSIRO theoretical physicist Dr. Gerald Pereira and Mr. Adam Taylor, Head of Science at Footscray City College in Melbourne. Gerald and Adam have been Scientists in Schools partners for the past 18 months and in that time, Adam has explored many opportunities to utilise Gerald's expertise. Gerald has visited the school a few times to present, in layman's terms, his work on soft condensed matter physics. He also gave a talk to the Yr 11 class on career pathways from secondary school to scientist. Given Gerald's knowledge of physics, he was a very useful mentor to accompany the Yr 10 class on a visit to the Synchrotron earlier in the year. Since his workplace is nearby, the students also made a side visit there and were able to see first hand the computational modelling that Gerald and colleagues use to investigate complex problems posed by the mining industry. Adam informed us that Gerald "is very hip and cool and wears a leather jacket, debunking the stereotype of your typical physicist or mathematician".

The program is also open to PhD students who would like to volunteer their expertise to a teacher. Jerani Pettikiriarachchi is a postgraduate student in the Department of Materials Engineering at Monash University. She is partnered with Phil Carmody at Our Lady of the Sacred Heart College, a Catholic girl's college in Melbourne. Phil registered for Scientists in Schools because he observed that "the numbers (of girls) doing physics at year 11 and 12 are very low". Jerani has proven to be a fabulous role model for the students at OLSH by inviting them to Monash University for the day to experience a day in the life of a physicist. Using her University contacts, Jerani was able to take the girls on a journey through a Scanning Electron Microscope, the engineering of a race car, a wind tunnel and the physics involved in impact testing. Jerani later commented that "the students thoroughly enjoyed themselves and in the end Phil had to usher out a bunch of protesting girls".

There are also some excellent examples of scientists who are helping out teachers at rural and remote schools where day-to-day contact with scientists is more limited. When physicist and Chair of the Australian Institute of Physics (Victoria Branch), Dr. Nicoleta Dragomir registered for Scientists in Schools, she requested to be partnered with schools in country Victoria because she has a strong interest in encouraging girls to consider science. She recently visited her partner at Devon North Primary School armed with an Optics Suitcase obtained with a grant from the Optical Society of America. Each student from prep to Yr 6 had a chance to discover, by hands-on experience, that white light is made up of many different colours and how to assemble a polariscope. Nicoleta commented that "being given the opportunity to go and visit in person and work with the students was a thrill and a splendid experience."

Of course, the style and variety of partnerships does not end there. Each partnership is unique but are all united in their aim to promote a deeper understanding of the importance of science.

Recently, the team at CSIRO Education launched the subprogram, Mathematicians in Schools. Mathematicians in Schools incorporates all of the features that has made Scientists in Schools so successful in enhancing science education and science literacy in our schools but allows teachers to adopt a mathematical role model instead. Through Scientists in Schools and Mathematicians in Schools, over 1400 teachers are now partnered with a scientist or mathematician to enhance the engagement of students in their learning of science. It is a great formula which has real benefits for the teacher, students and scientists. It is also a great way for scientists to make contact to the community when students go home and talk about their experience with family.

I encourage the involvement of all scientists, mathematicians and teachers in this exciting national program. With your support and participation, we can motivate young people to pursue interests in science, and create and foster important links between school and science communities.

Scientists in Schools and Mathematicians in Schools are funded by DEEWR and managed by CSIRO Education. For more information and to get involved, go to *www.scientistsinschools.edu.au*.

Dr Jim Peacock is currently a CSIRO Fellow and Chair of the Science Team. He was the Chief Scientist of Australia (March 2006-August 2008) and the former Chief of CSIRO Plant Industry (1977-2003).

Prime Minister's Prize for Science

John O'Sullivan
2009 Prime Minister's Prize for Science

Image credit: Bearcage Productions

Nearly a billion people use John O'Sullivan's invention every day. When you use a WiFi network—at home, in the office or at the airport—you are using patented technology born of the work of John and his CSIRO colleagues.

They created a technology that made the wireless LAN fast and robust. And their solution came from John's efforts to hear the faint radio whispers of exploding black holes.

In 1977 John O'Sullivan co-wrote a paper about the use of a set of mathematical equations known as Fourier transforms to sharpen optical telescope images distorted by the atmosphere. The paper is short and, like O'Sullivan, somewhat humble. It builds on first principles of physics, but brings together a broad view joining radio and optics. And the paper is seminal. It explains the techniques known as adaptive optics and proves why they work.

What's truly remarkable is that the consequences of that paper are now at work in millions of homes, airports, cafés, offices, hotels and universities across the world. They have cut the cables that tied computers to the desk and turned laptops into ubiquitous social and business tools.

The wireless LAN story is a textbook example of how blue sky research can lead to the most practical of outcomes. It also explains how John O'Sullivan, an engineer from the esoteric world of radio astronomy, joined the world of commerce with Rupert Murdoch and Cisco before returning to his roots.

As an undergraduate at the University of Sydney, John did a dual degree in physics and electrical engineering, and then went on to a PhD in radio astronomy. After completing his doctorate, he set off in 1974 to work for a year on the Westerbork radio telescope in The Netherlands. Nine years and two children later, during which time he became head of the group responsible for the development and maintenance of the Westerbork's receiver systems, he was lured back to Australia as head of the Signal Processing Group in the CSIRO's Division of Radiophysics.

Amongst John's many research interests was the search for radio waves from exploding black holes—predicted in 1974 by Stephen Hawking. John didn't find them, but the techniques he and his collaborators developed to clean up intergalactic radio wave distortion eventually found expression as the technology in the wireless LAN.

Fourier transforms were the key to his work. They were essential for the new Australia Telescope at Narrabri, constructed for Australia's bicentennial. To simplify and speed up the transform task he worked with Austek Microsystems to create a computer chip to do the processing for him.

By 1990 CSIRO was looking for ways to commercialise its capability in radio physics. "We realised that our skills with antennas, signal processing, and radio design might allow us to cut the network cable that linked every office computer," John says. "From the beginning we set out to match the speed of the best wired networks of the time."

But reflections got in the way. In the confines of buildings and rooms, radio waves bounce off many surfaces, so that a transmission arrives at a receiver followed by a series of echoes. This leads to a fuzzy, ambiguous signal, akin to 'ghosting' on a television.

Through his long association with radio astronomy, CSIRO Fellow and former Australia Telescope director, Ron Ekers says, O'Sullivan was equipped with at least three tools to bring to bear on the problem—knowledge that a solution lay somewhere among the many signal processing techniques astronomers were already using, an ability to conceive of what electromagnetic waves look like under Fourier transformation, and an understanding that it was possible to design a chip that could be fitted into a computer to undertake the necessary processing. "He already knew how to approach the problem, and he knew that it would work." Using the same techniques he'd applied to astronomy, John and his team realised they could send the information over many different frequencies and recombine the signal at the receiver.

Within a year, in 1992, CSIRO applied for an Australian patent and the long process of prototyping, trialling, and then commercialising and defending the technology and the patent, began.

The US patent came in 1996. The solution was so successful, that IEEE, the global standards body, wrote it into one of its standards for wireless networking, 802.11a. It is now part of two subsequent standards, 802.11g and n. But it took until April 2009 to agree on licensing terms with the makers of wireless computers.

The wireless LAN technology continues to change the world. It's built into the next generation of mobile phones and is set to transform how we interact with our cars and homes.

Amanda Barnard
2009 Malcolm McIntosh Prize for Physical Scientist of the Year

Every new technology brings opportunities and threats. Nanotechnology is no exception. It has the potential to create new materials that will dramatically improve drug delivery, medical diagnostics, clean and efficient energy, computing and more. But nanoparticles—materials made small, just a few millionths of a millimetre in size—could also have significant health and environmental impacts.

Amanda Barnard hopes to predict which nanoparticles will work most efficiently and which could be dangerous. Using supercomputers, she's making the particles in the virtual world and testing how they interact in various environments before they get made in the real world. Her peers told her it couldn't be done. But this young scientist proved them wrong and now leads the world in her field of nanomorphology—predicting the shape, structure and stability of nanoparticles.

Amanda didn't know what she wanted to do when she left school. She tried various artistic pursuits before turning to a physics degree at RMIT.

Nanoscience caught her attention. "The rest of the course was covering well known ground. But there was so much that was unknown in nanoscience—so much to discover," she says. A first class honours degree led to a PhD which she completed in 17 months, creating an analytical theory and computer model that predicted and explained the various forms of nano-carbon at different sizes. It was the first study of its kind that was recognised by both the theorists and the experimentalists and resulted in 17 journal publications and a book chapter.

The study opened the way to a distinguished postdoctoral fellowship at the Argonne National Laboratory near Chicago, then to a senior research fellowship at Oxford where she investigated how the stability of nanoparticles relates to safety and the environment, and wrote a commentary on nano-hazards for Nature Materials. This topic was revisited in her Nature Nanotechnology commentary earlier this year. As you take a known substance and turn it into nanoparticles its properties change. Nanoparticles of gold for example are usually red or purple but can be almost any colour.

So are nanoparticles safe? Amanda has been looking at titania nanoparticles which are used in photovoltaics in solar cells, sunscreens, and on self-cleaning surfaces. There are questions about the potential toxicity of these particles, as exposure to UV light creates free radicals. Amanda has created predictive 'maps' of how the particles will behave at various sizes or shapes, and in various thermal and chemical environments. She will be able to predict what happens when these nanoparticles wash away into our rivers and oceans.

Amanda is now pursing these questions back in Australia. She returned in 2008 with the help of a University of Melbourne Future Generation Fellowship. She is now a Queen Elizabeth II Australian Research Council Fellow and heads CSIRO's Virtual Nanoscience Laboratory.

Image credit: Bearcage Productions

Amanda's work requires serious computing power so she is a significant user of the National Computational Infrastructure at Australian National University. With nearly 12,000 high performance processors and 36 terabytes of memory this supercomputer can speed through her simulations.

Her current projects illustrate the breadth of application of her modelling.

For instance, she has helped create a way of delivering chemotherapy drugs using diamonds. Nanodiamonds are non-toxic but have reactive surfaces that can carry drugs. They also cluster together, so the release of the drug is slow and sustained. Using her theoretical knowledge of diamonds and the national supercomputer she found that an electrical charge would gently break the particles apart, so changes in pH could be used to influence delivery.

Now Amanda is part of an international consortium developing a chemotherapy patch using nanodiamonds. The team has already shown in animal trials that twenty times less drug will be needed—reducing the side-effects of chemotherapy.

In other projects she is exploring the properties of fluorescent biolabels for use in cancer diagnosis, regenerative medicine and gene therapy. She is also modelling the reactive properties of metal nanoparticle as next generation fuel catalysts. She hopes to make predictions that will ultimately improve both their stability and their performance.

And she is starting to bring human elements into her work, by creating models that explore how the benefit and risk profile of a product affects our willingness to purchase that product. How much risk will we accept? What combination will deliver optimal economic and environmental sustainability?

All this is just the beginning. Thousands of products are on their way. Amanda's tools are going to play a critical role in helping us safely reap the benefits of nanotechnology.

Len Altman
Excellence in Science Teaching in Secondary Schools

Geoscience is at the heart of some of humanity's biggest challenges in the 21st Century: access to water; alternative energy sources; and adapting to climate change. "So why," asks Len Altman, "Are students in our schools more likely to learn about the moons of Jupiter or the rings of Saturn than about the planet Earth and its history?"

Len is changing that at Marden Senior School and at the schools in his region and state. Along the way he is helping more young people discover science, and helping mature students discover new careers in the minerals industries.

Len Altman was going to be a dentist—that's what his mother wanted. But once he was at university it was clear he had made the wrong choice and Len dropped out. He needed work and found it as a geoscience technician with McPhar, a small geophysics company. The work took him exploring around South Australia and then to Canada where he re-entered university, obtaining a geophysics and geology degree from the University of British Columbia in 1972.

A downturn in the minerals industry saw him back in Adelaide and looking for work. South Australia was looking for science teachers and offering anyone with a science degree a job. So Len jumped into teaching, bringing with him his love of geoscience.

Thirty six years later Len is still teaching. He teaches science and maths at Marden Senior College in the eastern suburbs of Adelaide. His enthusiasm for geology still shines through and he's introducing students of all ages to the potential of geoscience. The number of students doing geoscience has doubled during Len's time and his students have led the State in their end of year assessment.

Many of his students have secured jobs in geoexploration. Others have been inspired by his example to pursue science teaching themselves. One says, "Having Len as a teacher was a great experience for me. He stood out . . . showed such passion for the work. He encouraged and mentored me and was inspirational . . . he made me aware of the possibilities and went the extra distance by supporting my transition into a new pathway."

Len believes that geoscience has an important role in the school curriculum. "We need the earth sciences to help us find a sustainable future in everything from water to alternative energies, geosequestration and the search for new minerals. We need to give our students the conceptual and thinking skills to understand how our planet works, and to help them participate in an informed debate about the future."

"Furthermore, younger students love the hands-on approach of geoscience. There are indeed strong reasons for geoscience to be included in school curricula, at all levels," he says. Len is doing much to spread the word.

Image credit: Bearcage Productions

He regularly creates opportunities for primary school students to participate in activities in secondary school laboratories and for his own students to participate in activities in universities and TAFE colleges. He also mentors trainee science teachers at Flinders University. He organises geoscience careers nights in collaboration with other schools. They report increased interest in science as a result.

He coordinates the national Teacher Earth Science Education Programme in South Australia—promoting, organising and presenting a series of training workshops in Earth and Environmental Science, for teachers throughout the state. He has led the creation of Geoscience Pathways—a website which aims to change attitudes towards the Geosciences by demonstrating their essential contribution to modern society. To date, it has brought together 14 schools, nine universities and 23 companies to share ideas, resources and projects. The results are clear. Marden now has more students in geology and geoscience than any other school in South Australia. And Len's influence is spreading. Geoscience is again on the rise across South Australia.

Written by Niall Byrne and Tim Thwaites

Other recipients of the Prime Minister's Prizes for Science

WA teacher Allan Whittome received the Prime Minister's Prize for Excellence in Teaching in Primary Schools for his achievements in engaging young students in science

Monash University researcher Michael Cowley received the 2009 Science Minister's Prize for Life Scientist of the Year for his contribution to our understanding of metabolism and obesity

Further information at *https://grants.innovation.gov.au/SciencePrize*

The man behind an identity in quantum electrodynamics

by F. J. Duarte

Introduction

The 6th of May, 2010, marks the 10th anniversary of the passing of John Clive Ward a quiet genius of physics whose ideas and contributions helped shape the post-war quantum era. Since John was an Australian citizen it is only appropriate to remember him in the pages of this journal. First, as a manner of introduction, I will outline John's most salient contributions. Then, I will attempt a description of the physicists, teacher, and friend that I was privileged to know.

Physics

In an approximated chronological order the contributions of John Ward began with a paper published (with Maurice L. H. Pryce) in *Nature* as part of his doctoral research at Oxford (Pryce and Ward, 1947). This was a solution to a problem, that according to John was posed by Dirac, and that J. A. Wheeler had tried to solve (Ward, 2004). The suggestion to tackle this problem was made by Pryce (a former student of R. H. Fowler and John's supervisor). This had to do with the decay of γ particles and the emission of two correlated photons in opposite directions. John correctly predicted the angular distribution of the photon polarization and that these quantum results were incompatible with classical descriptions. Soon thereafter John's prediction was confirmed by experiment (Wu and Shaknov, 1950). These were the first publications that made explicit the incompatibility of quantum mechanics with local theories (Dalitz and Duarte, 2000). Nevertheless, these early entanglement papers remain largely unrecognized.

Next, following a conjecture of Dyson (1949) in his second paper, on the equivalence of the quantum electrodynamics theories of Feynman, Scwhinger, and Tomonaga, John introduced his celebrated *Ward Identity* in a very succinct paper (Ward, 1950). This paper was followed by a set of identities a year later (Ward, 1951). Today Ward's contribution is also known in a modified context as the *Ward-Takahashi Identity*.

Then came the collaboration with Salam on the development of the *Standard Model* (Salam and Ward, 1961, 1964a, 1964b). The conversations of John on this topic were sporadic and when they did occur he expressed uneasiness about Salam's propensity to publish prematurely. This is explained at length in his memoirs (Ward, 2004) and became a topic of interest in the recent book *Cosmic Anger* (Fraser, 2008). More about this later.

In addition to these Herculean contributions John collaborated with well-known mathematicians and theoreticians thus producing a series of brilliant papers on: the Ising Model (Kac and Ward, 1952), quantum solid-state physics (Ward and Wilks, 1952), quantum statistics (Montroll and Ward, 1958), and Fermion theory (Luttinger and Ward, 1960). His last paper was on the Dirac equation and higher symmetries (Ward, 1978).

In a piece written in an Oxford publication it was once stated that Ward "has contributed deeply to an astonishingly broad range of theoretical physics: statistical mechanics, plasma physics, quantum electrodynamics, and particle physics" and the writer continues "*he has drawn attention to basic truths, and has laid down basic principles, which physicists have followed in subsequence decades, often without knowing it, and generally without quoting him.*" (Dunhill, 1995).

A further appreciation of John's contributions came from Andrei Sakharov who classified him as one of the "*titans*" of quantum electrodynamics alongside Dyson, Feynman, Schwinger, and Tomonaga (Sakharov, 1990). More recently, we have also learned that John Ward was among the early pioneers in the application of *Feynman diagrams* (Kaiser, 2005). I should emphasize that for as long as I knew John he never mentioned this.

In December 1988, in Lake Tahoe, I was introduced to Julian Schwinger. As soon as he knew that I came from Macquarie he asked "Do you know John Ward? Is he difficult to get along with?" Throughout the 1990s I had a number of conversations, and corresponded, with Willis E. Lamb on quantum measurements. In several occasions our conversations would end on the topic of John Ward as Lamb, who knew him from the 1950s, had great admiration for John's physics.

Days at Macquarie

The first time I heard the name John Ward was in the first semester of third year physics. Some of my fellow physics students using a somewhat mysterious tone used to mention a brilliant physicist due to lecture us. It was 1976 and

we were taking quantum mechanics with Guy Fletcher, a Cambridge physicist. Fletcher was an excellent teacher and wrote neatly on the board. For the second part of the course came John Ward. By contrast, he spoke softly and mumbled a lot. He kept on looking at the board, wrote in a peculiar cryptic style, and kept on shaking coins in his pocket while sometimes talking so softly that it was impossible to make sense of what he was saying. That was my first impression of the brilliant theoretician. Not a good one indeed, especially since I was interested in getting a good grade in the course.

Some of my fellow physics students using a somewhat mysterious tone used to mention a brilliant physicist due to lecture us.

John was a tall fellow and kept himself in fairly good shape. At the time he was about 52. He wore thick glasses and sometimes stylish clothing. He also taught us solid state physics. As I became more used to his mannerisms the lectures became clearer and sometimes extremely lucid. This is all I can say about third year physics with John Ward. As I went into my physics honours year, in 1977, John and I began to interact in the physics tea room due to the issue of the *science reform movement* which was created to reform the degree structure of the university via the introduction of a B.Sc (that would be added to the universal Oxbridge style BA). Then, something extraordinary happened. John Ward as a full physics professor had a luxuriously large office. His secretary had an adjoined office. It turns out that for some reason John did not get along with her and decided to move out to a small bare office were he took a few books with him. Remarkably enough he suggested that I and a fellow post graduate student, Milan Brandt, move into his spacious office. So we did. By now the campaign for the B.Sc. had intensified. Parenthetically: when the science students revolted, with widespread support from the science faculty, and the physics faculty in particular, John assumed a valiant posture openly granting interviews to the press in support of the science cause.

Otherwise, John Ward, the man, was distant and profoundly immersed in his physics. During this time he even managed to publish a paper (Ward, 1978). I say "managed to publish" because with John, publication was only considered once a truly new piece of physics was produced. Besides, he was highly critical of himself which explains the relatively small number of publications that he authored and co-authored: about twenty in total. In addition he was a master of succinctness. His doctoral thesis was only 47 pages long (Ward, 1949). His paper on the incompatibility of quantum mechanics and local theories was less than 2/3 pages long (Pryce and Ward, 1947). The paper that eventually gave rise to the famed *Ward identities* was less than a ½ page long (Ward, 1950).

During our conversations in his bare office, at Macquarie, John often went back to his days at Aldersmaston where he participated in Britain's H-bomb effort.

Once, going through *The Feynman Lectures on Physics* (Feynman *et al.*, 1965) we came across the quantum representation of the polarization of the photon which was directly related to his 1947 paper and his doctoral thesis (Pryce and Ward, 1947; Ward, 1949). There, in a very tentative and shy manner, he conveyed to us that he was the first to construct those equations. But he did not actually say it in an explicit open manner it had to be almost deduced.

Perhaps because of his involvement in the British hydrogen bomb project, or perhaps due to a previous project with the Australian Atomic Energy Commission (Pryor, 1997), he was keenly interested in the performance of narrow-linewidth tunable lasers which was partly the topic of my doctoral research. One of the main applications for these lasers (Duarte and Piper, 1984) is atomic vapor laser isotope separation. Following afternoon tea, at the 8th floor of the Mathematics and Physics building, we would come down to the second floor and carry on the conversations in his small bare office. Topics would range from physics to the raging science battles. By this time he would mostly wear a light brown leather jacket and he would seat on a semi reclining oak chair that made an annoying noise every time he moved. He never bothered to have it fixed.

John's attitude towards the faculty was rather admirable. I never heard him say anything pejorative towards any member of the faculty. In fact, he hardly ever said anything about them. He thought highly of teaching and respected those engaged in that activity. In terms of interactions he seemed most at ease with people like Dick Makinson, Ron Aitchinson, Fredy Chong, Elmer Laisk, and later Jim Piper. One exception was the disagreement with Peter Mason the other physics chair at Macquarie. Peter, who was a generalist with interests in biophysics, decided not to support the science reform movement. On that issue John was highly critical of Peter's position but, very wisely, did not make that criticism public.

In general, John was very supportive, and regarded highly, the electronic engineering faculty. He had great admiration for anything practical. Let us remember that prior to being a physicist he was an engineer (Ward, 2004). This admiration also applied to experimental physics. His attitude towards mathematics was different. He expected us physicists to do well in mathematics and I clearly remember him saying "almost all mathematics is trivial." Whether he meant that as a joke, or not, he never elaborated further. However, John perfectly understood the enormous importance of a good mathematical education and he encouraged us to take courses in applied mathematics. Being in a unique *School of Mathematics and Physics* a friendly rivalry existed between us and the mathematicians thus we never questioned John's comment. In addition to Professor Chong the school had several well-known mathematicians including A. G. R. McIntosh, R. H. Street, and of course J. E. Moyal. A perspective on mathematics at Macquarie, during this time, is given by Ann Moyal (2006).

It is difficult to describe John's sense of humor. He did tell a few engineering jokes but what I remember most is his ability to laugh at unusual situations. For instance, he laughed

particularly hard every time we outwitted our political opponents. One hot summer morning, at the tea room, we were informed that a package had arrived. The postgraduate, for whose experiment the package came in, said: "Have to walk a whole bloody mile." To which I pointed out: "It is only 1.61 kilometers." Immediately, John began to laugh while repeating "only 1.61 kilometers."

Around campus, and in physics circles, he was known as eccentric and peripatetic. His incomplete hair cuts, apparently done by himself, did nothing to dispel this image. It was also peculiar, that in modern times, he still took a boat to America. He lived in Pymble, not far from Macquarie, where he had a large house surrounded by tall old trees. The house was nearly empty, almost completely devoid of furniture. At the center of his spacious living room, with ample windows in the perimeter... a grand piano.

As the number of post graduate students grew John decided to teach a course at the honours level called Topics in Physics. Topics included general relativity, quantum mechanics, and physics relevant to our experimental work. He would lecture in one class and set up an assignment problem for the next one. At the problem session he would call on one of the students to offer a solution. In one of those sessions I was asked to discuss my solution to a problem related to the diffusion of an electron in a plasma within cylindrical coordinates. I proceeded using a Fourier approach. As I went along I noticed John, on my peripheral vision, getting increasingly restless. Unperturbed I continued until I wrote down the final answer. It had taken me about 20 minutes and a lot of equations. John said nothing and proceeded to clean the board. Half board later, in about five minutes, he arrived at the same solution. The master of succinctness had made his point.

John openly discouraged his physics students from pursuing a theoretical career. The uncertainty of his younger years probably had a lot to do with this attitude (Ward, 2004). As such, he never took a Ph.D. student despite open efforts by some mathematicians. More explicitly, John was highly critical of some "Ph.D. factories" in theoretical physics. On various occasions he used the word "rackets" to refer to some of those establishments.

When it came to politics John had no definite ideology. He was a truly independent thinker. He cherished individual freedoms and was critical, and suspicious, of big government. He detested corruption and waste of taxpayer's money. In this regard, he thought that the education of the young, via subjects that required critical thinking, was important. There was also a humanitarian side to his ethos. It was John who made it possible for Dick Makinson to come to Macquarie as an Associate Professor knowing full well that Dick had gotten himself in trouble for his left wing tendencies. Also, for a long time John supported financially the widow of one of his former friends. I learned this by looking at his papers, after his death, since he never mentioned it.

Greg Sheridan wrote in *The Bulletin*: "One of Ward's few close friends at Macquarie is a young Chilean postgraduate student, Frank Duarte... The two make an odd couple

John openly discouraged his physics students from pursuing a theoretical career.

– the restrained, rather distant Englishman and the intense, earnest South American" (Sheridan, 1980). This was a fair observation since we came from very distinct backgrounds. In my opinion the factors that cemented our friendship were physics and an elusive sense of righteousness. Then, there were the peripherals. John praised my political maneuvering and willingness to speak to crowds. Also he repeatedly mentioned my ability to be seen in the company of attractive young ladies. One day that he brought this up I replied: "But John, you are *the professor*, why don't you get a beautiful young secretary?... I've seen many in administration." He replied, while laughing in a shy manner: "That's why! *those bastards* get the first pick."

In 1981 I accepted a postdoc in laser spectroscopy, with Brian Orr, at New South Wales. At this time I also began to correspond with some US researchers interested in experiments to test Bell's inequalities. When I discussed this with John he advised me to work on very sensitive interferometers instead. He was neither bothered by issues of interpretation nor did he have doubts on the correctness of quantum mechanics. Later when I had to describe a newly invented *N*-slit laser interferometer I did it using Dirac's notation to the dismay of some of my colleagues. The description is valid for either single-photon illumination or illumination using an ensemble of indistinguishable photons as in the case of narrow-linewidth lasers (Duarte, 1993). John was pleased. His thoughts on quantum mechanics are beautifully expressed in his memoirs (Ward, 2004).

The Year 1979

1979 turned out to be a year of contrasts. First, following two years of an intense political and academic campaign, the Academic Senate of Macquarie University finally approved the introduction of a B.Sc degree. As science rebels we were victorious in a confrontation important to us and described as a "nasty, bitter, bureaucratic struggle" (Sheridan, 1980).

Secondly, that year a Nobel Prize was given for the Standard Model of particle physics… and John was left out. He was annoyed. In his memoirs he refers to a premature disclosure by Salam as a factor in this episode.

While preparing the article for *Physics Today* (Dalitz and Duarte, 2000) I was enlightened by some long conversations with Dick Dalitz, a particle physicist, who himself was a giant of Australian physics known for the *Dalitz Plot* and the *Dalitz pair*. Dick was a life long friend of John via an interaction that apparently began when Dick independently derived John's results on the quantum polarization of the photon back in 1948 (Ward, 2004). Dick, who was intimately aware of John's abilities and theoretical know-how, told me that he spent a lot of time studying the Salam-Ward papers and his conclusion was: "John's contribution to the Standard Model was a lot more than popularly accepted." Also, P. W. Anderson conveyed to me, that among his peers, there were those that thought that John should have been included. An additional, and interesting, perspective (related to Salam) is

provided in the book *Cosmic Anger* (Fraser, 2008). Years later, in 1999, this issue surfaced again. By then, it was apparent that John had moved beyond this omission.

Final Conversations

When I came to the US we maintained sporadic contact via mail. Once he moved to Vancouver, to be relatively close to his sister Mary, he called me and thus began a series of phone conversations that revolved around current issues of physics, and my experiences in industrial America, with him occasionally warning me about "imbeciles."

John loved Mexican food and when in Canada he would visit down south to sample authentic cuisine. He also liked good seafood and several times brought up his wish of sampling Chilean lobsters. Thus, we arranged for a rendezvous. On December 29, 1999, at 11 am my brother Henry and I met John at the Sheraton, in Santiago. He had flown from Punta Arenas (Southern Chile). Almost 17 years had passed but he was the same John. We sat down over a bottle of wine and lunch as he commented that with our shorts and hats we looked Australian more than anything else.

He needed a new pair of glasses and that afternoon we took him to an optics shop, in downtown Santiago. It was a hot afternoon so afterwards we sat at a cheap bar to drink beer prior to visiting an internet café to check on some physics sites. It was then that we noticed that all was not well with John. He became very tired and began to sweat profusely. We took a taxi back to his hotel. We agreed to have dinner next time at our house located at the foot of the Andes Mountains in the East part of Santiago. We picked him up from his hotel in my 1971 Bronco. Like a young man he could not hide his joy while riding propelled by a roaring V8 engine. After introducing him to my parents we sat on a table under a traditional grape vine canopy. Soon John and Henry were engaged in a detailed discussion on international finances and Australian tax law which demonstrated yet another facet of John's complexity. During dinner we mainly discussed geopolitics. After tea he asked me for photographs of my children (he knew two of them as toddlers, Rosa and Frank) and, in a moment of reflection, expressed regret at not having a family of his own. John had been briefly married whilst in the US but never remarried.

We met again for most of the day the 1st of January, 2000 at the Sheraton where we had lunch. By now, John regarded *our reform of Macquarie* as one of the most important accomplishments of his life. His eyes sparkled as he reminisced on the subtleties of the campaign. I would also add that the creation of a fine physics program at Macquarie, based on *The Feynman Lectures on Physics*, was a great contribution to the university and to the lives of many students who were fortunate enough to experience it. In retrospect it is clear that the significance of John's physics, or his vision, were neither understood nor appreciated by the Macquarie establishment.

Back in Western New York, one early afternoon by mid April, 2000, I was doing some experiments when John called from Vancouver. He thanked me for his updated internet page and laughed when I told him of a small insert in *The Australian Physicist*, celebrating the 50th anniversary of the *Ward Identity*. At the end of this conversation he told me that he was not well. He called once again to let me know that he was going to a hospital. He had a respiratory disease. His sister Mary said that John's mind was clear until the end and requested that his memoirs be passed on to me for publication.

During our conversations in his bare office, at Macquarie, John often went back to his days at Aldersmaston where he participated in Britain's H-bomb effort. The theme came up again during our meeting in Santiago. Months after his death, while looking at his papers, I found correspondence between him and historian Lorna Arnold. Albeit Arnold pays due respect to John's absolute brilliance, as a physicist, she concludes that John's design was an "advanced concept… However, it was not developed" (Arnold, 2001). Unaware of Arnold's project Dick Dalitz and I spent considerable effort on this subject while we were preparing the article for *Physics Today*. We wrote and discarded many drafts of the article and at one stage Dick said: "We cannot leave it for the historians." The paragraph in our article includes the sentence "Ward had independently conceived a two-stage device" (Dalitz and Duarte, 2000).

References

1 Arnold, L. (2001). Britain and the H-Bomb, Palgrave, London.

2 Dalitz, R. H., and Duarte, F. J. (2000). John Clive Ward. Physics Today 53 (10), 99-100.

3 Duarte, F. J. and Piper, J. A. (1984) Narrow linewidth high prf copper laser-pumped dye-laser oscillators, Appl. Opt. 23, 1391-1394.

4 Duarte, F. J. (1993). On a generalized interference equation and interferometric measurements, Opt. Commun. 103, 8-14.

5 Dunhill, M. (1995). Professor John Clive Ward, in Postmaster and The Merton Record, Oxford University, Oxford.

6 Dyson, F. J. (1949). The S matrix in quantum electrodynamics, Phys. Rev. 75, 1736-1755.

7 Feynman, R. P., Leighton, R. B., and Sands, M. (1965). The Feynman Lectures on Physics, Addison Wesley, Reading.

8 Fraser, G. (2008). Cosmic Anger, Oxford University, London.

9 Kac, M. and Ward, J. C. (1952). A combinatorial solution of the two- dimensional Ising model, Phys. Rev. 88, 1332-1337.

10 Kaiser, D. (2005). Drawing Theories Apart: The Dispersion of Feynman Diagrams in Postwar Physics, University of Chicago, Chicago.

11 Luttinger, J. M. and Ward, J. C. (1960). Ground-state energy and many-fermion system, Phys. Rev. 118, 1417-1427.

12 Montroll, E. W. and Ward, J. C. (1958). Quantum statistics of interacting particles; general theory and some remarks on properties of an electron gas, Phys. Fluids 1, 55-72.

13 Moyal, A. (2006). Maverick Mathematician. Australian National University, Canberra.

14 Pryce, M. H. L., and Ward, J. C. (1947). Angular correlation effects with annihilation radiation. Nature 160, 435.

15 Pryor, A. W. (1997). Personal memories of two advanced enrichment projects at Lucas Heights in the years 1972-1980. The Australian & New Zealand Physicist, 33 (3-4), 53-58.

16 Sheridan, G. (1980). Australian physicist wins Guthrie medal. The Bulletin 101 (5239), 49-50.

17 Sakharov, A. (1990). Memoirs, Knopf, New York.

18 Salam A. and Ward, J. C. (1961). On a gauge theory of elementary interactions, Nuovo Cimento 19, 166-170.

19 Salam A. and Ward, J. C. (1964). Electromagnetic and weak interactions, Phys. Lett. 13, 168-171.

20 Salam A. and Ward, J. C. (1964). Gauge theory of elementary interactions, Phys. Rev. 136 B, 763-768.

21 Ward, J. C. (1949). Some Properties of the Elementary Particles, Oxford University, D. Phil. Thesis.

22 Ward, J. C. (1950). An identity in quantum electrodynamics, Phys. Rev. 78, 182.

23 Ward, J. C. (1951). Renormalization theory of the interaction of nucleons, mesons, and photons, Phys. Rev. 84, 897-901.

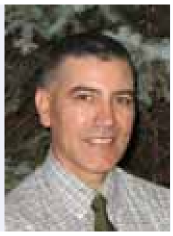
24 Ward, J. C. (1978). General relativity, the Dirac equation, and higher symmetries. Nat. Acad. Sci. 75, 2568.

25 Ward, J. C. (2004). Memoirs of a theoretical physicist. Optics Journal, Rochester (Available at http://www.opticsjournal.com/ward.htm).

26 Ward, J. C. and Wilks, J. (1952). Second sound and the thermo-mechanical effect, Phil. Mag. 43, 48-50.

27 Wu, C. S. and Shaknov, I. (1950). The angular correlation of scattered annihilation radiation, Phys. Rev. 77, 136.

Dr. F. J. Duarte (FAIP) is a research physicist based in Western New York, USA. He introduced the generalized multiple-prism dispersion theory, discovered various dispersive oscillator configurations for tunable lasers, and is working on very large N-slit interferometers.



Perceptions of Physics

by Paul Evans

Abstract:
How do students actually perceive Physics and Physics-related careers? How does this perception develop? Is there a difference between how the male and female perception develops? What are the reasons for (or not) studying senior Physics? As a Physics teacher these are intriguing questions that established a motivation and curiosity to research how students perceive Physics.

The following is an extract from the research that the author is presently undertaking at the University of the Sunshine Coast. This is funded by the regional Science Centre for Innovative and Professional Practice (SCIPP) and as such, the focus of the study is on state and independent schools from Queensland's Sunshine Coast.

Introduction

Prior to the economic blip of the global financial crisis there seemed to be plethora of articles and reports[1, 2, 3] that painted a picture of doom and gloom regarding the number of students studying Physics at all educational levels; although it is acknowledged that at the end of 2008, AIP published some positive news regarding University Physics enrolments[5].

Equally alarming was the supposed dire consequences this dearth of students, teachers and consequent lack of skilled employees was having on the nation's, and global economy.[1, 3, 4]

As a Queensland high school Physics teacher there was the motivation and curiosity to research what was happening in Queensland and pose a range of interrelated questions. Deciding on which question to focus was certainly a quandary; although, there has been some research into the general perceptions of Science and the influence into the subject selection process[6, 7] there did not seem to be any research that specifically targeted Physics and based on Queensland and more specifically the Sunshine Coast.

Methods

Preliminary research was instrumental in producing a modified student questionnaire and evolving the study to incorporate a Physics teacher's questionnaire. Both questionnaires incorporated a likert rating scale that allowed quantitative analysis.

Additionally, qualitative data was obtained with semi-structured focus groups that gathered student and teacher opinions that enriched the quantitative data providing an opportunity for the participants to discuss their feelings and rationale about a variety of issues.

The Research cohort and Quantitative data

Students:
- Cases: 212   8 Schools (3 state, 5 Independent)
- Gender: Male - 81 (38.2%); Female - 131(61.8%)
- Physics Students: 66 students (31% of cohort) studying Yr11
- Gender of Physics students: Male - 69.3%; Female -30.7%
- % of Gender selecting Physics: Male-55.6%; Female-15.5%

Teachers:
- Cases: 21   Males: 18   Females: 3
- Average age: 45.3 years
- Average number of years teaching: 18.8 years
- Average Industry experience: 2.7years; 14 teachers – between 0 - 2 years experience
- Qualifications: BSc in Physics, Maths, Engineering or Geology

Qualitative data: - yet to be fully and completely analysed

Students:
- Cases: 39   6 Schools (3 state, 3 Independent)
- Gender: Male - 18 (46%); Female - 21(54%)
- Physics Students: 19 students (49% of cohort) studying Yr11

Teachers:
- Cases: 6   Males: 6   Females: 0

This evidence supports the notion that students consider Physics challenging, and appreciate that in order to study it one has to commit time and effort, both inside and outside the classroom, and have a level of aptitude for mathematics.

This quantitative data alone is not unsurprising when coupled with the qualitative data of the focus groups; this understanding of the commitment required has an impact on students' selection to study Physics, as indicated by the following quote:

Table 1
The main perceptions of Physics

As a Subject	As a Career
• Challenging – 93.3% and Interesting – 71.1%	• Challenging - (73%) yet Interesting - (50.2%)
• Need to think in the class– 92.7%	• Difficult - (49.3%) yet Rewarding - (43.6%)
• Time and effort needed outside class – 91.2%	• Unaware of the career opportunities - (26.5%)
• Yr10 Mathematics at least grade B – 85.2%	
• Not many career opportunities – 79.7% (31.8%) unsure	
• Rewarding – 72.3% and Useful in the future -72%	

Table 2
Reasons for (or not) selecting to study senior Physics

Reasons to select senior Physics	Reasons why not to select senior Physics
• Interested – F (88%): M (84%)	• Not required for degree - F (73%): M (54%)
• Felt could succeed – F (80%): M (78%)	• Not Interested – F (67%): M (57%)
• Good Yr 10 results – F (64%): M (64%)	• Too much time - F (40%): M (57%)
• Good Science teacher in Yr 10-F (46%): M (54%)	• Maths too difficult – F (43%): M (43%)
• Contextual nature - F (60%): M (50%)	• Too theoretical – F (42%): M (38%)
• Required for degree - F (57%): M (57%)	• Physics in Yr 10 too hard – F (40%): M (34%)
	• Another reason – F (44%): M (46%)

"I would have liked to do Physics but didn't think I could handle three science subjects as I thought they would be hard. As Biology and Chemistry were pre-requisites for more courses and I thought Physics was the hardest, I didn't do Physics. People tell me that Physics isn't that intense now (due to the new contextual syllabus), so I could probably handle it"

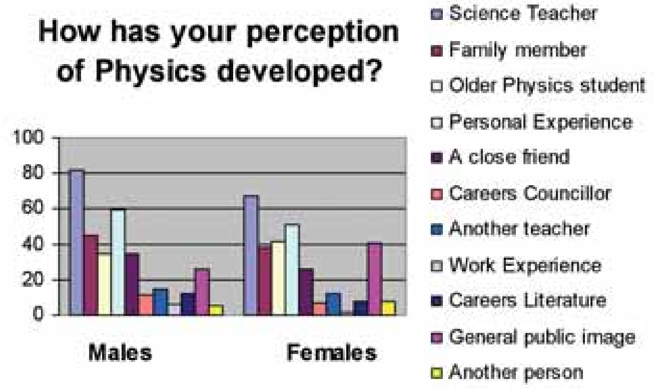
Students are choosing subjects strategically, they acknowledge the commitment required but given that Physics is no longer a university pre-requisite for numerous courses they are opting for different subject combinations. This is further enhanced with the data from Table 2

It appears that female students are significantly aware of the impact of pre-requisites and use this as the major criterion in not selecting Physics. On closer scrutiny of "another reasons" for not selecting Physics – timetable clashes and curriculum organisation appeared almost a third of the time; this equates to 14 students.

Encouragingly, this data indicates that students are selecting Physics for interest and a sense that they can succeed, frequently as a result of success in Year 10 Science. Success undoubtedly breeds confidence, which manifests itself in considering the subject as a viable option.[6, 7, 8]

In Table 1, it is alarming to note that the perception of Physics as a subject is characterised by students not being aware of the career opportunities. Science teachers up to and including Year 10, (who are unlikely to be Physics specialists) are not actively promoting the subject on the basis of career opportunities; indeed, on analysis of the Physics teachers questionnaires less than half of the Physics teachers teach more than one Year 8, 9, or 10 Science class; predominantly and unexpectedly, 90% are teaching Year 11 and 12 Physics, but their second area of teaching (81%) is senior Mathematics not junior Science. This data is supported by research on who is teaching Physics[9, 10, 11].

Figure 1
How has this perception of Physics developed?



Equally as worrying was the revelation that, although Physics teachers readily promote career opportunities (71%) when teaching, less than a third are confident their careers knowledge is current and would welcome the opportunity to attend a careers presentation.

How has this perception of Physics developed?

Notably from Figure 1, it is the Science teacher that is the greatest contributing influence to the development of students perception; which although expected[1, 12] it confirms this earlier research and outlines that for both females and males it the major factor. These findings were again supported by the qualitative data;

"The old teacher was excellent, but we got a new physics teacher this year (actually 2 new teachers) which has made it a lot harder as I don't understand their teaching style which has made me dislike physics as we don't do any experiments and have to teach myself at home with the textbook. I think that it's hard to get a good physics teacher!"

The Science teacher and personal experience are instrumental in influencing the perception of Physics but there is also scope to enlighten parents and older Physics students including friends regarding the importance students place on their opinions[6, 7, 8, 12]. Additional research also identified the Science teacher (56%), parents (47%) and older students (39%) as the three groups of people who have the greatest impact when making decisions about subject selection of Science subjects.

Again, it is observed that careers information and careers counsellor are not prominent in helping students develop their perceptions; however, it must be noted that they do play a role, albeit minor, in helping students with subject selection - 33% and 29% respectively.

Conclusions and Questions

There is a plethora of interpretations and comments one can make regarding the collected data and the following is just the beginning.

• The Science teacher is crucial in developing a student's perception and helping making subject selection choices. This is eloquently expressed by a quote from a student that epitomises the need for quality Physics teachers:

> *"I believe that teachers are incredibly important in shaping our perceptions of Physics. If your Physics teacher is inadequate / boring, then the subject itself becomes boring. Physics is a subject that desperately needs to be taught by competent, passionate, patient teachers"*

• Student's perception of Physics as a career and a subject is that it can be challenging yet interesting, rewarding and useful in the future; however, many are unsure of the career opportunities after studying Physics and that careers literature and careers counsellors play a secondary role in supporting and developing students perceptions and assisting them make subject selection choices. Is there a role for the AIP to be producing careers literature and supporting teachers to promote the numerous career opportunities?

• The largest proportion of the junior Science curriculum, is being taught by non-Physics specialists. This is undoubtedly a supply and demand issue but do those non-Physics teachers possess the knowledge and passion to engender interest in Physics?

• Students are selecting subjects strategically; if Physics is not a university pre-requisite, then students will choose what they consider an 'easier option'. If there are timetable clashes then students will again select the 'easier option', as students perceive the subject as requiring a lot of time and effort both inside and outside the classroom.

Hopefully this research will continue the dialogue of discussion, as evident in many research papers[13, 14] and suggest recommendations about adopting strategies. Teachers and careers counsellors have access to current careers literature that enlightens students to the diversity of careers that can be embarked upon as a result of studying Physics.

Curriculum designers appreciate the strategic selection of subjects and maybe increase the timetabled time allocation to Physics; have Physics taught as a separate science or unit rather than embedded in the homogenous junior science – on reflection only 19% of students were confident that they could describe Physics at the end of Year 9; this increased to 30% at the end of year 10 – yet school curriculum requires students to make subject choices at the end of Year 10 and sometimes end of Year 9.

Queensland has undergone extensive reviews of the science, technology, engineering and mathematics (STEM) education[3, 4, 13, 14] and the implementation of some of these recommendations has commenced. Despite these collaborations, evidence from the teachers' focus groups indicates significant concerns with the assessment procedure of the 2007 Physics syllabus. Nevertheless, there are even greater overarching issues within the educational spectrum, for instance the Australian (National) Curriculum[15, 16] will be introduced in 2011, even though the content and assessment procedures are still in a state of flux.

Needless to say, whatever happens, there must be a long term strategy to address the shortage of Physics teachers as this study demonstrates they are far and away the most influential factor on establishing student's perception of Physics.

Note

Of the 21 Physics teachers, only the author is a member of the AIP; with 4 others being approached for membership – many years ago.

References

1 Department of Education, Science and Training skills audit 2006: retrieved form:

http://www.dest.gov.au/sectors/science_innovation/publications_resources/profiles/science_engineering_technology_skills_audit_report.htm last accessed December 2008

2 OECD Global Science Forum policy report May 2006 'Evolution of Students Interests in Science and Technology Studies' *http://www.oecd.org/dataoecd/16/30/36645825.pdf* last accessed December 2008

3 Queensland Government Department of Education, Training and the Arts 2007

'Towards a 10-year plan for science, technology, engineering and mathematics (STEM) education and skills in Queensland' – Discussion paper

*http://education.qld.gov.au/projects/stemplan/docs/stem-discussion-paper.pd*f - last accessed December 2008

4 Queensland Government Department of Education, Training and the Arts 2007

'Towards a 10-year plan for science, technology, engineering and mathematics (STEM) education and skills in Queensland' – Update at:

http://www.qsa.qld.edu.au/downloads/learning/pd_con_snr_school_kuhnemann.pps#1 – last accessed December 2009

5 Jennings, P., De Laeter J., Zadnik, M. and Lloyd B. (2008) 'Physics Enrolments – more good news', Australian Physics, Volume 45, number 5 p166

6 Lyons, T. (2003) 'Decisions by science proficient Year 10 students about post-compulsory high school science enrolment: A sociocultural exploration', unpublished PhD thesis, UNE School of Education

7 Lyons, T. (2004) 'Choosing Physical Science courses: The importance of cultural and social capital in the enrolment decisions of high achieving students', paper presented at the International Organisation for Science and Technology Education IOSTE XI Symposium, Lublin, Poland, 25th - 30th July 2004.

8 Panizzon, D and Westwell M. (2009) 'Engaging students in STEM-related subjects. What does the research evidence say? *http://www.flinders.edu.au/shadomx/apps/fms/fmsdownload.cfm?file_uuid=A5917489-C8D7-01A1-D537-13FFAA534FEB&siteName=flinders* last accessed December 2009

9 Goodrum, D., Hackling, M., & Rennie, L. (2001). The status and quality of teaching and learning of science in Australian schools: A research report. Canberra, ACT: Department of Education, Training and Youth Affairs (DETYA).

10 Harris, K-L., Jensz, F., & Baldwin, G. (2005). Who's teaching science: Meeting the demand for qualified science teachers in Australian secondary schools? Report prepared for the Australian Council of Deans of Science. Melbourne, Victoria: ACDS.

11 Lyons, T., Cooksey, R.W., Panizzon, D. L., Parnell, A. and Pegg, J. E. (2006). Science, ICT and Mathematics Education in Rural and Regional Australia – The SiMERR National Survey (Final Report). Canberra: Department of Education, Science and Training.

12 Hattie, J. (2003). Teachers make a difference: What is the research evidence? Paper delivered to the Australian Council for Educational Research Conference

http://www.educationalleaders.govt.nz/Pedagogy-and-assessment/Building-effective-learning-environments/Teachers-Make-a-Difference-What-is-the-Research-Evidence last accessed December 2009

13 Rennie, L. J. & Goodrum, D. (2007). Australian school science education national action plan 2008-2012 Background research and mapping. *http://www.dest.gov.au/sectors/school_education/publications_resources/profiles/australian_school_education_plan_2008_2012.htm* last accessed December 2008

14 Panizzon, D and Westwell M. (2007) 'Future SACE Mathematics and Science Innovation Program: Research briefing: Participation, engagement and achievement in mathematics and science education'

http://www.flinders.edu.au/shadomx/apps/fms/fmsdownload.cfm?file_uuid=945E9C05-A8D8-78BE-4E65-2B3F27494F1E&siteName=flinders - last accessed December 2009

15 Masters, G. (2009) A Shared Challenge: Improving Literacy, Numeracy and Science Learning in Queensland Primary Schools: Australian Council for Educational Research.

http://education.qld.gov.au/mastersreview/pdfs/gov-response-masters-review.pdf last accessed December 2009

16 National Curriculum Board, Shape of the Australian Curriculum: Science May 2009 *http://www.acara.edu.au/verve/_resources/Australian_Curriculum_-_Science.pdf* last accessed December 2009

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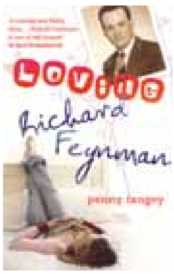
Review



Loving Richard Feynman
Penny Tangey
University of Queensland Press, 2009
ISBN 9780702237256

'Loving Richard Feynman' will catch the eye of anyone who's taken university physics and heard some of the legends surrounding his name. And those who read it will be unable to resist next reading a copy of 'Surely you're joking, Mr Feynman!', his collection of outrageous anecdotes.

Tangey's book is a series of diary entries – letters to Feynman – written by 15-year-old Catherine, a science nerd who idolises her scientist dad and finds a new idol in Feynman. She loves the poster of him that she has placed on the wall "perpendicularly adjacent" to her desk. Catherine writes to "Dear Professor Feynman" and later to "Dear Richard Feynman" and later still to "Hey Richard" about what's happening in her life.

Alongside her commentary on and responses to her journey through 'Surely you're joking', he gives her a safe outlet to discuss her family crisis, her resentment of an intellectual competitor at school, her changing social role, her non-crushes on boys, and the political content of knitting. She rations her reading of his book to one chapter per week and delights in his exploits ... until she reads about his experiment on how to pick up women. Then her teenage adoration turns to moral outrage and condemnation.

The events in Catherine's life and her growing emotional maturity are cleverly parallelled with her relationship with Feynman as she reads his book and learns more about him. The people in Catherine's own world are revealed as more complex than she had thought, real people worthy of forgiveness and understanding, while the reader travels with her to a deeper understanding of Feynman's character, circumstances and failings.

As a female physicist, I want to urge Physics teachers everywhere to read this book and then lend it to their English teacher colleagues. They might then consider it for their school curricula, and a few more young women may be encouraged to enter Feynman's world… 'Loving Richard Feynman' has a great scatter of laugh-out-loud quotes and would support discussions on the failings of parents, the difficulties of the nerd in mainstream Australia, the human frailties behind all role models, peer pressure, ethics in science, and the unfair snobbery nowadays directed at the cappuccino.

Dr Susan Feteris
Monash University

Samplings

Fish inspire wind farm configuration

http://physicsworld.com/cws/article/news/40993

An array of Windspire vertical turbines made by US-based Mariah Power: Robert Whittlesey and John Dabiri believe they have worked out the best way to arrange such turbines. (Credit: Devon Bank)

Conventional wind turbines work best when located as far as possible from the destructive vortices of neighbouring turbines. However, a pair of scientists in the US have worked out that the performance of other kinds of turbine actually improves when they are placed close to one another, concluding that wind farms could therefore be made much smaller than they are today.

The familiar propeller-like turbine with a horizontal axis of rotation can convert 50% or more of the wind energy from it is exposed to. In a wind farm, however, the wake from one turbine will disturb the air reaching the blades of its neighbours meaning turbines must be placed far apart. A less familiar family of turbines have a vertical axis of rotation. Individually, these vertical-axis turbines are less efficient than the horizontal-axis devices but they have a significant advantage – their power output can be increased when they are placed very close to one another.

Now, Robert Whittlesey and John Dabiri of the California Institute of Technology have worked out how best to arrange such closely spaced turbines by drawing on the work of aeronautical engineer Daniel Weihs, who showed in the 1970s how fish save on energy by swimming within schools. Such fish form a series of offset rows, and Weihs found that fish get carried forward by the vortices created by the swimming motion of their two closest companions in the row immediately in front of them. Using this principle, Whittlesey and Dabiri found that a staggered column of alternately clockwise- and anticlockwise-rotating turbines significantly enhances the speed of rotation. The reason, they say, is that the presence of neighbouring turbines concentrates and accelerates the wind. They found that vertical-axis turbines arranged in this way could produce a power per unit area 100 times that of existing, horizontal-axis wind farms.

APS rejects plea to alter stance on climate change

http://physicsworld.com/cws/article/news/40916

The American Physical Society (APS) has “overwhelmingly rejected” a proposal from a group of 160 physicists to alter its official position on climate change. The physicists, who include the Nobel laureate Ivar Giaver, wanted the APS to modify its stance to reflect their own doubts about the human contribution to global warming. The APS turned down the request on the recommendations of a six-person committee chaired by atomic physicist Daniel Kleppner from the Massachusetts Institute of Technology.

The committee was set up by APS president Cherry Murray in July, when the society received the proposal for changing its statement, which had originally been drawn up in November 2007. It has spent the last four months carrying out what the APS calls “a serious review of existing compilations of scientific research” and took soundings from its members. “We recommended not accepting the proposal,” Kleppner said. “The [APS] council almost unanimously decided to go with that.”

The official APS position on climate change says that “emissions of greenhouse gases from human activities are changing the atmosphere in ways that affect the Earth’s climate” and adds that there is “incontrovertible” evidence that global warming is occurring. The APS also wants reductions in greenhouse-gas emissions to start immediately. “If no mitigating actions are taken,” it says, “significant disruptions in the Earth’s physical and ecological systems, social systems, security and human health are likely to occur.”

Some of the on-line comments posted after this article make interesting reading – the debate is not confined to Australia!! See also in Science: *http://www.sciencemag.org/cgi/content/full/326/5955/926*.

Up, up and away

When hot vapor comes in contact with a cold surface, such as a shower wall, liquid droplets are created that quickly coalesce and form a film. This condensation process is ubiquitous in natural as well as artificial environments. In industrial settings, preventing film formation is generally desirable because liquid films are poor heat conductors. However, it can be challenging to remove the droplets more quickly than they coalesce, particularly when nonvertical sample orientations preclude help from gravity.

Boreyko and Chen demonstrate the spontaneous elimination of droplets from a horizontal surface. They prepare a superhydrophobic substrate consisting of carbon nanotubes deposited on silicon micropillars. Video imaging of the condensation of ambient moisture reveals that, after the droplets are formed, they initially coalesce without moving, then eventually reach a mobile phase where several droplets fuse and leave the surface of the sample in a dramatic out-of-plane jump. The energy for the jump is provided by the decrease in surface energy gained by coalescence; the average condensed droplet size is an order of magnitude smaller than that observed in gravitational removal.

Interestingly, a similar mechanism is thought to be used by a type of mushroom to eject a spore from its sterigma. [*Phys. Rev. Lett. 103*, *184501 (2009)*].

Special relativity passes key test

http://physicsworld.com/cws/article/news/40834

Scientists studying radiation from a distant gamma-ray burst have found that the speed of light does not vary with wavelength down to distance scales below that of the Planck length. Lorentz invariance stipulates that the laws of physics are the same for all observers, regardless of where they are in the universe.

In over 100 years Lorentz invariance has never been found wanting. However, physicists continue to subject it to ever more stringent tests, including modern-day versions of the famous Michelson–Morley interferometry experiment. This dedication to precision stems primarily from a desire to unite quantum mechanics with general relativity, given that some theories of quantum gravity – including string theory and loop quantum gravity – imply that Lorentz invariance might be broken. In particular, these theories allow for the possibility that the invariance does not hold near the minuscule Planck length – about 10^{-33} cm – since at this scale quantum effects are expected to strongly affect the nature of space–time.

It is not possible to test physics at the Planck length directly because this length corresponds to an energy of around 10^{19} gigaelectronvolts – way beyond the reach of particle accelerators (the most powerful of which, CERN's Large Hadron Collider, will generate collision energies of around 10^{4} gigaelectronvolts). However, this latest research, carried out by a collaboration of physicists under the leadership of Jonathan Granot of the University of Hertfordshire in the UK, has provided an indirect test of Lorentz invariance at the Planck scale.

Vitaly Ginzburg: 1916–2009

http://physicsworld.com/cws/article/news/40896

Vitaly Ginzburg, who was one of the most significant theoretical physicists of the 20th century, died on Sunday 8 November at the age of 93. Ginzburg shared the 2003 Nobel Prize for Physics with Alexei Abrikosov and Tony Leggett for their work on the theory of superconductors and superfluids.

Ginzburg's Nobel prize centred on his work on "type-II" superconductors - materials in which superconductivity and magnetism can co-exist. They differ from "type-I" superconductors, which completely repel magnetic fields. In 1950 Ginzburg, together with Lev Landau, introduced a parameter to describe the interaction between the superconductor and the magnetic field, and went on to show that superconductiivty and magnetism could only co-exist if this parameter is greater than 0.71.

Vitaly Ginzburg in 2003. (Credit: Maria S Aksenteva)

Soft is strong

http://www.nature.com/nature/journal/v462/n7269/full/462045a.html

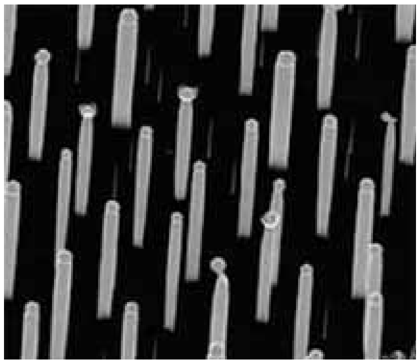
For hundreds of years, scientists have wondered how glass-forming liquids solidify without crystallizing as they cool — or indeed without undergoing much change in structure at all. Glass artists take advantage of this continuous rigidification process to create and preserve liquid 'form' and 'action', fascinating onlookers as they turn glowing globs of hot molten glass into elegant shapes. The artists take care to use a glass-former that converts to a solid over a wide range of temperatures, so that they have time to work their magic. Other glass compositions make the transition from fluid to solid much more suddenly, and it would be impossible to work with them.

Glass-forming liquids that soften quickly on heating are described as being fragile, whereas those that don't are 'strong'. The same distinction is made to describe the behaviour of liquids under compression — fragile liquids 'jam up' suddenly into glasses under pressure, and strong ones don't. But we don't know why. Now, Mattsson et al. (*http://www.nature.com/nature/journal/v462/n7269/full/nature08457.html*) report that the same pattern of strength and fragility holds for certain colloidal suspensions, and that they do know why. This offers hope that colloids could be used as model systems to help describe liquid behaviour.

'Universal' equation describes how materials behave at nanoscale

http://physicsworld.com/cws/article/news/40884

Understanding how materials behave at tiny length scales is crucial for developing future nanotechnologies and continues to be a great challenge for both theoretical and experimental physicists alike. Now, a physicist at the Institute of Electronics, Microelectronics and Nanotechnology (IEMN) in Villeneuve d'Ascq, France, has borrowed from 19th century physics to come up with a new "universal" equation that predicts how size affects the key physical properties of nanometre-sized structures, which behave very differently from their macroscopic counterparts.



Nanowires created by researchers at NASA's Ames Laboratory: An equation developed by Grégory Guisbiers could help with the development of technologies based on similar nanoparticles. (Courtesy: NASA)

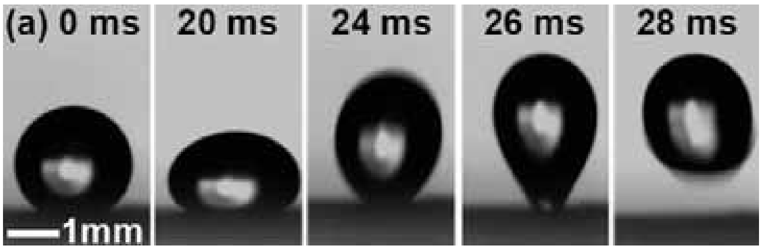
Guisbiers developed his equation by analysing and comparing how the size of nanoparticles affects the temperature at which they melt, become superconductors and become ferromagnetic (Curie temperature). He also considered the Debye temperature, which is related to how lattice vibrations conduct heat in a material. These four "characteristic" temperatures are key physical quantities for any material and all are inter-related: the melting temperature is proportional to the Curie temperature, to the square of the Debye temperature and to the square of the superconducting temperature.

Predictions obtained from the equation agree very well with experimental data on melting and superconducting behaviour of nanoparticles – of silicon or lead, for example. The theory agrees fairly well with experimental results for ferromagnetism and lattice vibrations – the discrepancy is less than 10%. "This is an acceptable value because the model is quite simple and only requires knowledge of the size, shape and spin situation of the particles involved," adds Guisbiers. The work will be reported in Physics Letters A.

Lotus leaves shake off water

http://physicsworld.com/cws/article/news/40866

Many plants are extremely water-repellent owing to their rough textures, which can trap air to provide a waterproof cushioning. In some cases, plant leaves are so repellent that no droplets can stick at all; instead, they simply bounce and roll off. A lotus leaf is an example of a natural material that possesses this "superhydrophobicity", and a pair of scientists in the US are proposing that natural vibrations lie at the heart of the phenomenon. If the effect can be mimicked by materials scientists, it could lead to a range of novel applications.



Vibration-induced transition from sticky to non-sticky state of a drop of more than 90% water at a frequency of 80 Hz and a peak-to-peak amplitude of 0.6 mm. (Credit: The American Physical Society)

In the past few decades researchers have had a lot of success at mimicking rough surfaces in nature in order to make water-repellent materials. One key limitation, however, is that engineered rough surfaces do not retain water repellency when water condenses on the surface, rather than landing as water droplets. Some structures in nature, such as the lotus leaf, do not suffer from this limitation and always maintain their water-repellency.

Chuan-Hua Chen and Jonathan Boreyko of Duke University claim that they have found a physical explanation for this natural advantage, which is that the lotus leaf may use wind-induced vibration to shake off water condensate that may have otherwise penetrated their rough surfaces. [*see Phys. Rev. Lett. 103, 174502 (2009)*].

Quantum speed limit

Phys. Rev. Lett. 103, 160502 (2009)

The processing speed of computer chips has doubled almost every two years for the past 40, as engineers have crammed ever more transistors into smaller circuits. But according to Lev Levitin and Tommaso Toffoli of Boston University in Massachusetts, chips will ultimately hit a roadblock, limited by the minimum time it takes for a particle to flip from one quantum state to another — a fundamental step in any information system.

There are two independent bounds on this minimum time — one based on the average energy of the quantum system, the other based on the uncertainty in the system's energy. In their calculations, Levitin and Toffoli unify the bounds and show there is an absolute limit to the number of operations that can be achieved per second by a computer system of a given energy. Levitin says that, at the current doubling pace, computing speed will reach this limit in about 80 years.

Electrons reveal DNA without destroying it

http://physicsworld.com/cws/article/news/40694

The recent winners of this year's Nobel Prize for Chemistry join a famous lineage of scientists who have shed light on the biomolecular world by using X-ray crystallography. However, new research published this week unveils an alternative to this famous technique that could reveal the structure and properties of biomolecules in much finer detail. According to its creators in Switzerland, the new method has the potential to revitalize biophysics, biochemistry and molecular biology.

Despite all its successes, however, the ultimate limitation of this technique is that it works by averaging over millions of molecules in a crystal. This inevitably means that some of the finer details of the molecular world could remain undiscovered. Moreover, there are many protein molecules that are very difficult or impossible to crystallize.

Now, Hans Werner-Fink and his team at the University of Zurich have suggested a way around this problem by creating a form of microscopy that utilizes lower-energy electrons, so as not to damage the delicate biological material. To demonstrate their new technique, the researchers isolated a strand of DNA and exposed it to a beam of low-energy electrons (up to 230 eV) over the course of 70 min. By tracking the electrons that are scattered elastically, the researchers were able to build up holographic images of the DNA.

Bacteria power micro-ratchet

http://physicsworld.com/cws/article/news/40760

In contrast to the random motion of tiny objects placed in a bath of molecules at thermal equilibrium, miniature asymmetrically shaped cog wheels rotate continuously in one direction when exposed to swimming bacteria. That is the finding of a group of Italian scientists who built ratchets just a few hundredths of a millimetre across and filmed their motion when immersed in solutions containing E. coli. The researchers say that such bacteria-propelled ratchets could be used to power micro-machines or potentially even provide a new macroscopic source of energy.

Roberto Di Leonardo and colleagues at the University of Rome "La Sapienza" have shown how to exploit the random motion of E. coli without controlling the bacteria in any way. They exploit the fact that a collection of bacteria immersed in a liquid represents a non-equilibrium thermodynamic system by virtue of the self-propulsion of the bacteria. This non-equilibrium system, they say, should confer ordered motion on an asymmetrically shaped object, in contrast to the random, Brownian motion, that thermal gas molecules would generate. This is exactly what they observed.

Di Leonardo and his colleagues note in their paper that they can foresee a completely new technology where "passive micro-devices can be fabricated and simply actuated by immersion in an active liquid".

Samplings by Don Price

Samplings continues on page 188

Product News

SciTech

Ultra-low noise CCDs for direct X-ray detection

Andor's iKon-M X-ray CCD cameras are designed to offer high-performance solutions to direct detection X-ray needs, and come in two variants: DO and DY. The DO variant interfaces easily with vacuum chambers, whereas the DY variant is a 'stand-alone' camera with beryllium input window.

The systems offer very low read noise floor, high QE across the X-ray, XUV and EUV range, and boast negligible dark current with thermoelectric cooling to as low as -90°C. The 1024 x 1024 array with 13 μm square pixels provides both high resolution and high dynamic range. iKon-M combines kHz readout for lowest noise floor and multi-MHz readout for faster frame rates, all through a convenient USB 2.0 interface.

Applications: Astronomy, Chemiluminescence/Bioluminescence, Fluorescence microscopy, High Throughput Screening, Biochip reading, Bose Einstein Condensation, Neutron Radiography, Semi-conductor analysis, Pressure sensitive paints, Laser Induced Fluorescence, HyperSpectral Imaging, Raman Imaging.

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Andor iStar ICCD Cameras for Time Resolved Imaging

Andor iStar is an ICCD camera for time resolved imaging with 25ps signal time resolution.

Andor allows you to fine-tune your experiment from any location around your optics table. With a push of a button on the wireless remote, you can change Gate Width, Gate Delay, MCP gain, etc. while optimizing the other parameters in your experiment.

A Digital Delay Generator (DDG™) is built right into the compact camera head. Micro components reduce both the propagation delay (as low as 35ns) and signal jitter, allowing complete user flexibility.

The iStar does NOT require any external controller box. The design, with onboard DDG™, eliminates the need for additional bulky apparatus saving valuable laboratory bench space, enhancing performance and providing easy control of the complete system. A single PCI controller card is all that is needed to run the system. Andor iStar has a Compact Head Size (206mm x 102mm x 129mm).

Andor's exclusive IntelliGate™ option simultaneously gates both the photocathode and Micro Channel Plate (MCP) eliminating the need for a pre-pulse or anticipator circuit. The ultra high-speed MCP gate pulse, switches on the correct potential (~800 volts) in a nanosecond timeframe. Benefits include: 1:10^7 on/off ratios in the deep UV; no requirement for a pre-pulse or an 'anticipator' circuit; full selection via software control.

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Andor's Single Photon Detection Camera

With the iXonEM+ 897, Andor have produced a dedicated, compact, truly

high-end platform, designed specifically to get the absolute best from Electron Multiplying CCD (EMCCD) technology. EMCCD technology is an innovative approach for amplifying very low light signals above the read noise floor of the CCD, which would otherwise set the detection limit of the system, whilst harnessing the full Quantum Efficiency (QE) of the silicon sensors.

What sets iXon apart from other EMCCD cameras on the market:

- Even single photon signals are amplified above the noise floor. The full QE of the CCD chip is harnessed (no intensifier)
- RealGainTM: absolute EMCCD gain is selectable directly from a linear and quantitative scale
- TE cooling down to -100°C (-85°C fan-cooled): critical for elimination of darkcurrent detection limit
- Up to greater than 90% QE: maximum possible photon collection efficiency
- Reduced Noise: enables higher dynamic range

Applications include: Single Molecule Microscopy, Live Cell Microscopy (including Confocal), Calcium Signalling, Transport/Motile Imaging, Intracellular Bioluminescence, Fluorescence Microscopy, Photon Counting, Lucky Astronomy, Adoptive Optics, Bose Einstein Condensation/Ion Trapping, Single Molecule Detection/Nanotechnology, Neutron Tomography, X-Ray/Gamma Tomography, Plasma Diagnostics, Raman Detection

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Lastek

New pro Series Diode & Fiber Lasers from Toptica

pro Philosophy:
Best specifications, highest stability, optimized hands-off operation

pro Technology:
Flexure based mirror mounts, proprietary resonator design, machined from solid metal block

Offering best specifications and optimized hands-off operation, the pro series consists of tunable diode lasers (DL pro), amplified tunable diode lasers (TA pro), and frequency converted tunable diode lasers (DL/TA-SHG/FHG pro), as well as femtosecond fiber lasers (FemtoFiber pro).

All these new laser systems are based on successful and well-established TOPTICA products, that have been upgraded to a new level. The aim of these new laser systems is to make scientists life easier, so they can focus on science and not lasers. pro lasers are far more stable and easier to use.

The new diode laser systems are based on the DL pro, that was introduced in 2007. It tunes over the complete gain spectrum of the laser diode without any realignment, and mode-hop free tuning is greatly enhanced. Compared to other diode lasers, it is at least 10 times more stable against acoustical and thermal disturbances.

The TA pro also incorporates a new TA mount with thermal management and custom optics as well as newly designed flexure based mirror mounts with exceptional beam pointing stability. All SHG systems incorporate the monolithic SHG pro resonator. It is machined from a solid block, stable and dust proof.

DL pro Features:
• Standard models
780: 765 – 795 nm, 30 – 80 mW
850: 815 – 855 nm, 30 – 80 mW
940: 910 – 985 nm, 30 – 80 mW
1040: 980 – 1075 nm, 20 – 50 mW

New: Ultra-stable Tunable Diode Laser now at all Diode Wavelengths between 372 nm and 1670 nm

• NEW Motorized wavelength selection
Computer controlled
Typ. ± 0.2 nm accuracy
Typ. ± 0.01 nm repeatability

• Fine tuning
Typ. 30 – 50 GHz mode-hop free
Computer control option

• Extreme stability
Linewidth typ. 100 kHz
Frequency stability < 100 MHz / K
Highest robustness against vibration and acoustic noise

The FemtoFiber pro incorporates polarization maintaining fibers only and its resonator is completely fiber contained for stability and hands off operation.

Both novelties increase the robustness and reliability of the fiber laser even further.

The FemtoFiber pro is available with fundamental output at 1550 nm and also with second harmonic output at 780 nm.

The latter option is integrated in the same housing as the laser with a footprint of only A4.

Another integrated option is the generation of a supercontinuum which spans more than an octave in the frequency domain.

The combination of high pulse energies with very short pulse widths gives the highest peak powers on the market (regarding Erbium doped fiber lasers).

FemtoFiber pro Features:

* SESAM modelocking
* PM fiber assembly
* Pulse width < 100 fs
* Power > 350 mW
* Repetition rate 80 MHz

TOPTICA's pro series ensures technological leadership for modern physics experiments and scientific challenges.

For more information please contact:
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sales@lastek.com.au
www.lastek.com.au

Picoquant LDH-P-FA-530 Green Picosecond Pulsed Laser Diode Head

The new green diode laser ("LDH-P-FA-530") is based on a master-oscillator fibre-amplifier (MOFA) concept with frequency conversion. The master oscillator generates spectral narrow picosecond pulses at 1064 nm at a variable repetition rate from 10 kHz to 80 MHz using the proven gain-switching technique from PicoQuant.

The output of this laser is directly connected to a Ytterbium-doped fibre amplifier (YDFA), which boosts the output from the seed laser by more than 10dB. This output is then directly connected to a fibre-coupled SHG waveguide, which converts the infrared laser emission to green emission (531 ± 3 nm) with a very high conversion efficiency. The final output of the LDH-P-FA-530 reaches up to 1 mW average output power at 40 MHz repetition rate.

The pulse width is <100 ps FWHM. The laser emits from a FC/APC fibre connector and can be either collimated or directly connected to suited optical fibres. The laser head can be driven by the PDL 828 'Sepia II', the PDL 800-D or the PDL 800-B. The all-fibre setup makes a topology with a several couplings and interfaces completely maintenance-free.

Features
- Centre wavelength: 531+/-3 nm
- Pulse width below 100 ps (FWHM)
- Up to 1 mW average output power
- Repetition rate from 10kHz to 40 MHz
- FC/APC fibre connector

For more information please contact:
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Ocean Optics NIRQuest Spectrometers
NIRQuest Spectrometers improved performance with more grating options. A high-performance optical bench, low-noise electronics and various grating options make NIRQuest Spectrometers truly extraordinary.

This new generation of small-footprint, near-infrared spectrometers is available in three models that cover various ranges between 900 nm and 2500 nm, and are ideal for applications ranging from analysing moisture content in food and beverage products to analysing trace metals in wastewater.

In addition to improved optical bench performance, NIRQuest Spectrometers are available with more grating options than our previous NIR Spectrometers. That allows users to take advantage of the different grating characteristics to maximise experiment setup.

NIRQuest Spectrometers

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	NIRQuest512	NIRQuest256-2.1	NIRQuest256-2.5
Detector:	Hamamatsu G9204-512 InGaAs linear array	Hamamatsu G9206-256 InGaAs linear array	Hamamatsu G9208-256 InGaAs linear array
Pixels:	512	256	256
Optical Resolution (FWHM)	~3.1 nm w/25 μm slit	~7.6 nm w/25 μm slit	~ 9.5 nm w/25 μm slit

Coherent

PI-MAX3: the smarter, faster ICCD camera

Princeton Instruments' PI-MAX series of intensified CCD cameras has set the standard for time-resolved imaging and spectroscopy for almost a decade. Now Princeton's PI-MAX3 takes ICCD performance to a new level with order of magnitude speed improvements and a host of new features to allow easier and more accurate time-resolved imaging.

PI-MAX3 is available in formats of 1024 x 1024 pixels for imaging and 1024 x 256 pixels for spectroscopy. Video frame rates can be achieved in the imaging format and spectral rates of thousands of spectra per second can be achieved.

Most importantly, the camera allows sustained gating at rates up to 1MHz: a 20-fold improvement over previous designs.

The camera includes the improved SuperSynchro timing generator, SyncMaster clock output, a compact "one-box" design, convenient GigE interface and much, much more.

For a detailed 50-page brochure contact Paul Wardill
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GeoLasPro Laser Ablation UV Optical System for ICPMS
The GeoLasPro takes full advantage of Coherent's world-leading excimer manufacturing expertise and combines it with sophisticated homogenising optics design to deliver unmatched energy fluences from 1 J/cm^2 to 45 J/cm^2 at 193 nm. The result is a high

performance, turnkey laser ablation ICPMS attachment for everyday use, solely and uniquely supported by the one manufacturer, now locally supported by Coherent Scientific. The GeoLasPro is compatible with most commercial ICPMS designs. Custom chamber designs are available.

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New, expanded range of solar lasers and process tools

Lasers are increasingly used in R&D and manufacture of crystalline silicon and thin-film solar cells. Applications include edge isolation, selective ablation, surface texturing, laser fired contacts and more. Coherent Scientific offers a complete suite of lasers and turnkey systems to address both R&D and volume manufacturing requirements. This includes Coherent's latest release of Aethon™ and Equinox™ turnkey process tools based on their Intelligent Optical Systems (IOS) product portfolio.

The Aethon™ workstation is optimised for R&D and process development, while the Equinox™ product range has been designed for production-ready, low-volume throughput, right through to high production throughput fabrication.

These systems take advantage of Coherent's broad range of Q-switched DPSS lasers (Avia), micromachining fibre lasers (Talisker) and high power quasi-CW lasers (Paladin) and low-cost, low maintenance, high performance benefits.

Please contact us to receive a copy of the latest "Laser-Based Tools for Solar Cell Production" brochures, application notes or further information contact:
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Verdi Family of CW High-Power Diode-Pumped Solid-State Lasers

Verdi is a family of compact all solid-state CW lasers with output powers up to 18W at 532nm and up to 25W at 1064nm. With more than 5,000 units installed worldwide, Verdi has earned its reputation as the benchmark for performance and reliability.

Released at CLEO 2009, the Verdi G-series is an optically pumped semiconductor laser (OPSL) version of the Verdi family, delivering 2 Watts and 5 Watts output power at 532nm.

The new Verdi G5 and G2 lasers, part of the new Verdi G-series based on Coherent Inc's unique OPSL technology, provides the same power, lower noise (<0.03% rms), and high quality, single-spatial mode (M2<1.1) output as earlier 2 Watt and 5 Watt Verdi lasers based on DPSS technology, but now has a 50% smaller foorprint and lower cost. This combination makes it an ideal source for pumping ultrafast or CW Ti:S lasers.

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Xantos excimer laser with integrated gas management

Coherent's Xantos XS is the world's first excimer laser featuring integrated gas management with a pre-mixed gas cylinder. The compact laser has

excellent static and dynamic gas lifetime and consumes only small amounts of gas, even when used at high duty cycles.

For the first time, a fully integrated "one-box"excimer laser is possible, with the gas supply, pumps and valves fully integrated into the laser cabinet.

The small integrated gas cylinder is sufficient to fuel the laser for many months of operation and all gas operations are conveniently carried out under software control. The result is a powerful, high-performance UV laser source requiring nothing more than a single-phase electrical connection.

The Xantos laser is available at wavelengths of 157, 193, 248 and 351nm and with repetition rates up to 500Hz.

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Each of us probably has some special "trick of the (physics teaching) trade." You may think your is too obvious, or well known, or trivial to justify a full note, but it may be just the sort of technique others would find useful. If you will send us a brief description of such practices along with any diagrams or images, we'll use them from time to time as space permits.

Warsash

New higher power, 594nm Laser from Warsash Scientific

Cobolt Mambo™ – compact DPSS laser at 594 nm now up to 100 mW

Warsash is pleased to announce the release of a higher power model of the already market leading orange laser from Cobolt AB, a Swedish manufacturer of low-noise DPSS lasers.

The Cobolt Mambo™ is a continuous-wave solid-state laser operating at a fixed wavelength 594 nm and with an output power of 25 mW, 50 mW and now 100 mW. It is thus perfectly suited for fluorescence analysis applications such as confocal microscopy and flow cytometry.

Built into a hermetically sealed compact package using the proprietary HTCure™ technology for extreme robustness, the Cobolt Mambo™ is a single longitudinal mode laser with low noise (<0.3 % rms), narrow spectral line width (typically <30 MHz) and exceptionally high beam quality (M2<1.1). The Cobolt lasers are based on proprietary PPKTP frequency conversion technology, for optimum flexibility and efficiency.

The Cobolt Mambo™ laser provides a compact solid-state and higher power alternative to HeNe lasers, which opens up a new range of fluorescence applications, in particular for the excitation of Alex Fluor 594, Texas Red and the new very bright gene expression proteins mCherry & mKate.

The laser is supplied with an ultra-compact controller (CDRH or OEM) which can be remotely accessed for operation and monitoring of the laser system via digital (RS-232) or analogue interfaces.

Cobolt now offers a complete range of high performance DPSS lasers to the fluorescence based bioanalytical industry: 355 nm, 457 nm, 473 nm,491 nm, 515nm, 532 nm, 561 nm, and 594 nm lasers are currently available at output powers from 10 to 1 W.

Lasers built using the HTCure™ Technology have shown to withstand multiple 60G mechanical shocks in operation without any sign of degraded performance. They can be exposed to extreme temperatures (>100 °C), and are insensitive to pressure and humidity. HTCure™ Technology is an advanced manufacturing technique for high-performance solid-state lasers that can provide exceptional reliability and performance for today's demanding applications.

Further information on these and laser solutions is available from:
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World's most compact and power efficient CW DPSSL at 355 nm Laser available from Warsash Scientific

Cobolt Zouk™ – compact DPSS laser at 355nm

Warsash is pleased to announce the release of the new Cobolt Zouk™,DPSS laser at 355nm from Cobolt AB, a Swedish manufacturer of low-noise DPSS lasers.

The Cobolt Zouk™ is a SLM, continuous-wave solid-state laser operating at a fixed wavelength 355 nm and with an output power of 10 mW. This makes it Ideal for exciting fluorophores used in flow cytometry or confocal microscopy called **Indo-1, Hoechst**, and **DAPI** which have a peak excitation at 350nm. The laser can also be used in microscopy for Ca+ uncaging, Raman spectroscopy, Microlithography & General research.

Based on a ring cavity design (patent pending), the Cobolt Zouk™ is the most compact and power efficient 355nm DPSS laser on the market with a laser head volume of only 366 cm² and power consumption less than 60 W. Built into a hermetically sealed compact package using the proprietary HTCure™ technology for extreme robustness, the Cobolt Zouk™ is a single longitudinal mode laser with low noise (<0.2 % rms), narrow spectral line width (<1 MHz), exceptional power stability (<2% over 8hrs with ±3°C) and very good beam quality (M2<1.1).

The laser is supplied with an ultra-compact controller (CDRH or OEM) which can be remotely accessed for operation and monitoring of the laser system via digital (RS-232) or analogue interfaces.

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Warsash Scientific appointed exclusive representative for Lighthouse Photonics

Warsash is pleased to announce that they have been appointed as the exclusive representative for Lighthouse Photonics in Australia & New Zealand. Lighthouse Photonics is a pioneer in providing sealed, turn-key, cost-effective, diode-pumped solid-state (DPSS) lasers for scientific research, industrial manufacturing and life sciences. Products include.

The flagship offering from Lighthouse Photonics is the Sprout™ - a compact, high-power, CW DPSS green laser for pumping all types of Ti:Sapphire laser: ultrafast, femtosecond, picosecond and CW. The Sprout™ provides up to 10 Watts continuous-wave (CW) power at 532nm in a near-perfect TEM00 mode with extremely low optical noise and excellent long-term stability. Sprout™ is truly a next-generation laser designed and manufactured using many years of experience to provide a sealed, turn-key source of collimated green light with high spectral purity.

The laser head is a monolithic 3-dimensional design for ruggedness and compactness. The fiber-coupled pump diode package, contained in the power supply, has an expected lifetime of more than 20,000 hours to minimize cost-of-ownership. The power supply also contains an integrated thermo-electrically-cooled (TEC) chiller. This purpose-built chiller is engineered to provide excellent reliability and reduced overall system footprint. Additional features of Sprout™ include automatic laser power control and USB/RS-232 interface for external monitoring and control.

- Compact laser head with Seal™ enclosure for long lifetime
- LockT™ mounting technology locks all cavity optics permanently in perfect alignment
- Long lifetime pump diode pack located in power supply and fiber-coupled to laser head
- Extreme low noise <0.03% rms with Noise Elimination Technology (NET™)
- World-class long-term power stability <±0.25% over 24 hours
- Closed-loop, purpose-built TEC chiller integrated in power supply

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New research casts doubt on impact of depleted uranium

Senior Research Fellow at the University of South Australia, John Pattison has led a research project that casts doubt on the aftermath impact of exposure to radiation from depleted uranium munitions.

The research recently published by the Journal of the Royal Society Interface (*J. R. Soc. Interface published online before Print Sept 23,2009, doi:1098/rsif.2009.0300*) investigated the health effects of the use of depleted uranium (DU) munitions which to date have carried the main blame for the cause of Gulf War Syndrome.

Pattison, with colleagues from Swansea University and the University of Birmingham, concluded that DU may not be as harmful from a radiation perspective as previously thought.

The study, conducted between 2006 and 2008, investigated the effect on the human body of exposure to DU in conjunction with natural background gamma-radiation in comparison to exposure to natural background gamma-radiation alone.

Pattison says the study results are in disagreement with recently published results and could play an important role in eliminating possible causes of Gulf War Syndrome.

"There is understandably a great deal of controversy surrounding Gulf War Syndrome - an umbrella term used to describe a range of illnesses thought to have arisen following exposure to DU munitions, either through ingestion, inhalation or the presence of fragments such as in shrapnel wounds," Pattison said.

"It has been claimed that the radiation dose from micron-sized particles of DU in the human body would be enhanced by a factor of 500 to 1000 upon exposure to naturally occurring background gamma-radiation (*New Scientist, 2672: 8-9, 2008*.

"Simply put, the claim has been that together these elements contribute a significant radiation dose in addition to the dose received from the inherent radioactivity of the DU.

"Many studies have been undertaken to discover more about Gulf War Syndrome but none has uncovered a direct cause or cluster of unique symptoms and that is why we need more research to clarify and refine our understanding of the syndrome.

"Our aim in this study has been to help by continuing the process of elimination and, in doing so; we believe that we can in fact rule out DU as a cause of the Syndrome from a radiation perspective. Our research found that the enhancement factor is actually of the order of 1 to 10 which, although significant, is at least 50 times smaller than has been suggested in the past."

Conferences 2010

May 24 - 26
Debris Flow 2010
Milan, Italy
http://www.wessex.ac.uk/10-conferences/debris-flow-2010.html

June 2 - 4
The 10th Meeting of the Shielding Aspects of Accelerators, Targets and Irradiation Facilities
Geneva, Switzerland
http://www.cern.ch/SATIF-10

June 8 - 11
Recent Developments in Gravity
Ioannina, Greece
http://neb14.physics.uoi.gr/

June 14 - 16
Heat Transfer 2010
Tallinn, Estonia
http://www.wessex.ac.uk/10-conferences/heat-transfer-2010.html

June 22 - 25
Western Pacific Geophysics Meeting
Taipei, Taiwan
http://www.agu.org/meetings/wp10/

June 24 - 26
International Symposium on Photonics and Optoelectronics (SOPO 2010)
Chengdu, China
http://www.scirp.org/conf/sopo2010/

June 27 - July 2
SPIE Astronomical Telescopes and Instrumentation 2010
San Diego, USA
http://spie.org/astronomical-instrumentation.xml?WT.mc_id=RCAL-AS

July 4 - 10
18th International Conference on Composites or Nano Engineering
Anchorage, Alaska USA
http://www.uno.edu/~engr/composite

July 11 - 16
9th International Conference on Excitonic and Photonic Processes in Condensed and Nano Materials (EXCON'10)
Brisbane, Queensland
http://www.cdu.edu.au/excon10/

July 12 - 16
The 7th Vigier Symposium: The Search for Fundamental Theory
London, UK
http://www.mindspring.com/~quantum.computing/index7.html

July 19 - 23
10th International Conference on Quantum Communication, Measurement and Computing
Brisbane, Queensland
http://qcmc2010.org

July 19 - 23
STATPHYS 24: The XXIV International Conference on Statistical Physics of IUPAP
Cairns, Queensland
http://www.statphys.org.au/

July 25 - 30
22nd International Conference on Atomic Physics (ICAP2010)
Cairns, Queensland
http://www.swin.edu.au/icap2010/

July 28 - 31
3rd Conference on Nonlinear Science and Complexity
Ankara, Turkey
http://nsc10.cankaya.edu.tr/

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, Australia
http://www.ica2010sydney.org/

August 30 - September 3
9th Quark Confinement and Hadron Spectrum
Madrid, Spain
http://teorica.fis.ucm.es/Confinement9

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, NSW
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

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

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