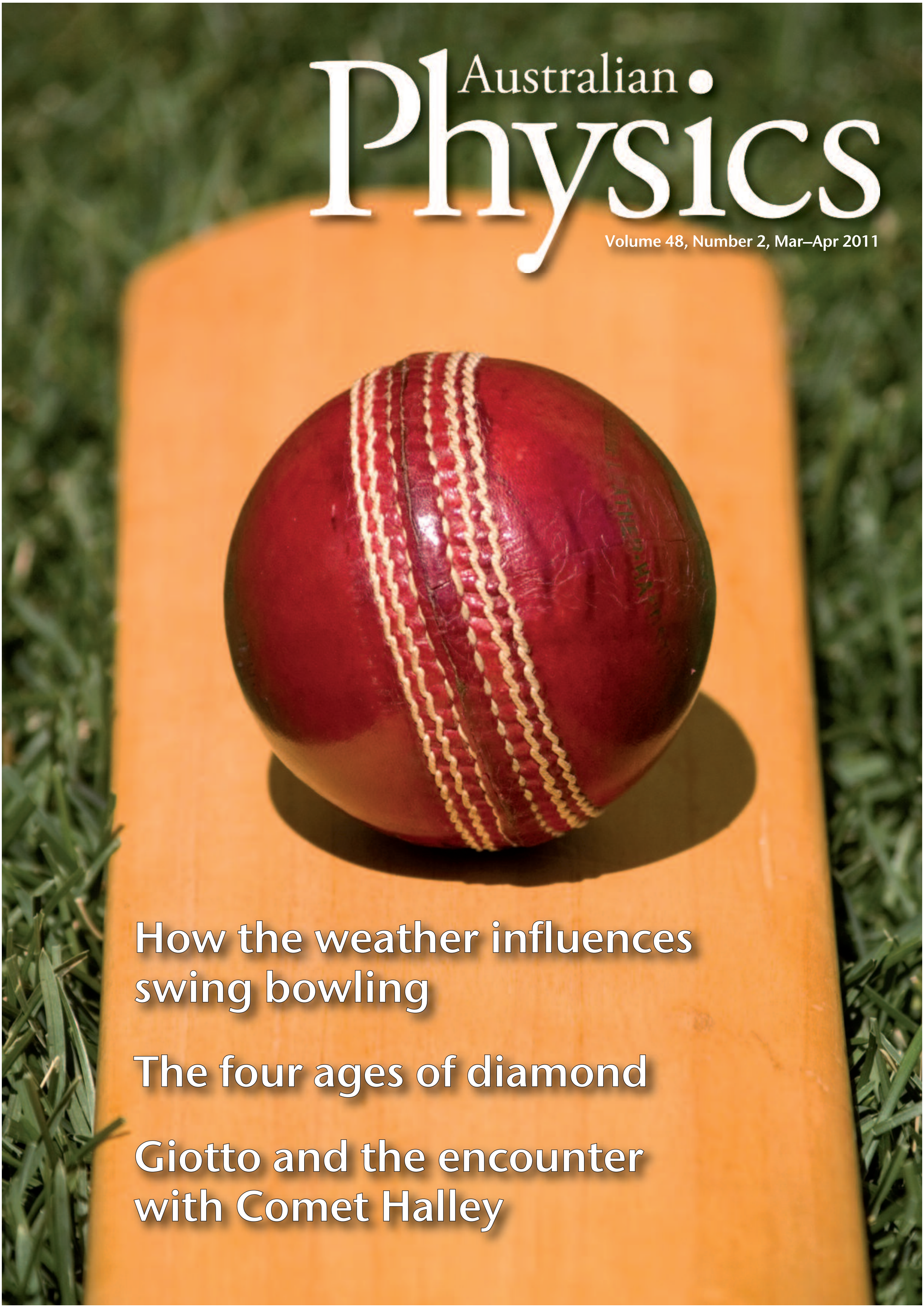

Australian Physics
Volume 48, Number 2, Mar–Apr 2011

How the weather influences swing bowling

The four ages of diamond

Giotto and the encounter with Comet Halley

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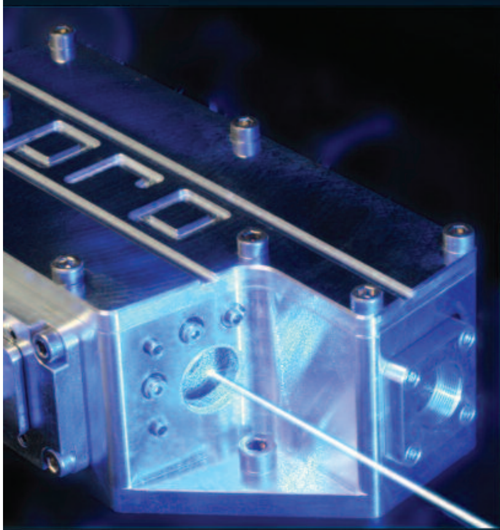
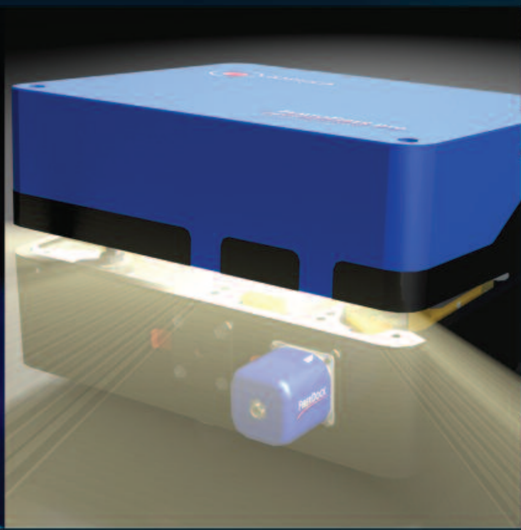
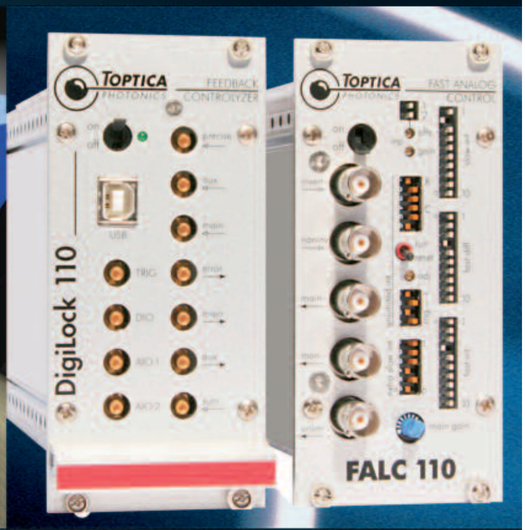

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2011 WALTER BOAS MEDAL

Background and Aims

The Medal was established in 1984 with the aim to promote excellence in research in Physics and to perpetuate the name of Walter Boas (University of Melbourne 1938–47, CSIRO 1947–69). The award is for physics research carried out in the five years prior to the date of the award, as demonstrated by both published papers and unpublished papers prepared for publication, a list of which should accompany the nomination.

Any AIP member may make a nomination or may self-nominate for the award.

Eligibility/Procedure

Nominees should be members of the AIP and Australian citizens and should have been residents of Australia for at least five of the seven years preceding the closing date for nominations. The Medal shall not be awarded more than once to any person.

The award shall be given for original research making, in the opinion of the examiners, the most important contribution to physics. This will be judged in papers published during the four years immediately preceding the date on which entries for the award close, supported where appropriate by unpublished papers or reports on work carried out during that period.

If a candidate considers that knowledge of work carried out prior to the four-year period is necessary for the correct evaluation of the record of work submitted for the award, reference may be made to the work where published, or an unpublished account of such previous work may be submitted.

Supporting Information

Candidates for the award should provide the following:

- A brief curriculum vitae covering personal details, academic and professional qualifications, outline professional career history, and honours and distinguished awards. A full CV is not necessary.
- A short account of the research achievements of the candidate (or candidates if there is a joint submission) setting out the achievements on which the application rests and drawing attention to those articles that are important.
- A list of relevant publications, patents and reports by descriptive title and reference related to the achievements on which the application is based. Where heavy reliance is placed upon material not reasonably available, a copy of this material may also be submitted.
- Candidates are invited to provide the names of up to three internationally known referees who have the appropriate expertise to offer a critical appraisal of the candidate's achievements.

Presentation of the Award

The award is conditional on the recipient delivering a seminar on the subject of the award at a meeting of the Victorian Branch of the AIP in November. The recipient is also expected to provide a manuscript based on the seminar for publication in *Australian Physics* magazine.

2011 AWARD FOR OUTSTANDING SERVICE TO PHYSICS IN AUSTRALIA

Background and Aims

The Australian Institute of Physics has several awards for excellence in some aspect of Physics. They are usually based on the research contributions of the individual or group concerned.

There are many individuals within the AIP who give great amounts of time and effort to the furtherance of Physics as a discipline. While some of these would also be contenders for one or other of the more research oriented awards, others would not. They tend to be quiet achievers, sometimes more devoted to teaching and its development than to research.

The AIP inaugurated an award for Outstanding Service to Physics in Australia in 1996.

Eligibility/Procedure

The award will be open to members of the AIP. Nominations may be made by a Branch Committee or by three members of the AIP. There will be no more than three awards nationwide in any one year and the Selection Committee, which will be appointed by the Executive, will reserve the right to make no awards in any one year.

The AIP Award for Outstanding Service to Physics will recognise an exceptional contribution on the part of an individual. Nominations should be accompanied by a clear one or two page citation describing the outstanding service given by the nominee.

TIMELINES

Nominations for both the Boas Medal and the Outstanding Service Award should be sent by **1 August 2011** to:

Dr Olivia Samardzic,
AIP Special Project Officer, 205 Labs, EWRD,
DSTO, PO Box 1500, Edinburgh, SA 5111, or
olivia.samardzic@dsto.defence.gov.au

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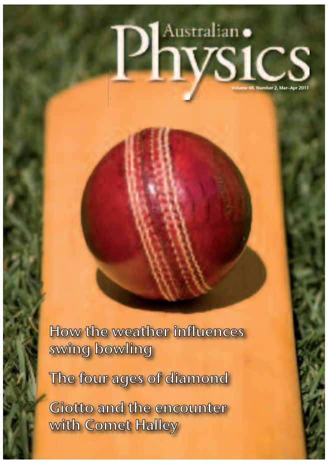

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EDITORIAL

A little publicity can go a long way

Our lead article in this issue on swing bowling is completely out of sync with the seasons. While most sports fans are passionately following their team in one of the football codes of Australian Football League, Rugby League or Union, or the World Game, few will be thinking of the summer subtleties of bowling. But it would be unfair on Jim McCaughan to delay any further in publishing his case for how the art of swing bowling in cricket is influenced by weather conditions.

As mentioned in a previous editorial, we warmly welcome articles in *Australian Physics* on the research by you and your colleagues. Some take the view that writing articles for a popular or even semi-popular readership is a waste of time, and all that matters is to maximise the number of papers in the best research journals. While outstanding research papers are of course the ultimate aim, the ability to explain the importance of your work to a broader audience should not be under estimated.

Plugging into the wider media can have unexpected and welcome consequences. A good example is the piece by Deborah Smith on the four ages of carbon on p. 41. Deborah is the science reporter for the *Sydney Morning Herald*. She picked up the story after seeing a report in *Australian Physics* of a talk Andrew Greentree had given to the Victorian Branch in June last year. The publicity from a full-page spread in a major Australian daily is difficult to quantify, but there is no question that the work of Andrew and colleagues, along with physics in Australia, has benefited overall.

We also feature an article by *The Age* columnist Perry Vlahos who celebrates the twenty-fifth anniversary of the flyby of Comet Halley by the *Giotto* space probe in 1986.

Finally, on page 38 it's a pleasure to introduce you to our nautical Book Review Editor, John Macfarlane.

IN OUR NEXT ISSUE: Volume 48, Number 3

- The birth of nuclear physics one hundred years ago
- Measuring Rutherford's impact on science
- Is Einstein still right? New cosmological tests of General Relativity

Physics in Asia and Science in Australia

It had been my intention in this issue to discuss the work of the Association of Asia Pacific Physical Societies (AAPPS) in some detail following its Council meeting in Pohang, Korea on 17–18 June. Sadly the vagaries of volcanic ash clouds saw me unable to leave Tasmania to attend. The AIP is a founding member of AAPPS and the Association is starting to build itself into a regional force in physics with a long term view of representing international physics in our region, in the same way that its European and North American counterparts do in their regions.

Although I was unable to attend the meeting and I can say a little about what was discussed. The AAPPS is made up of the physics societies from Australia, China, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, Mongolia, Nepal, New Zealand, Philippines, Singapore, Thailand and Taipei. In a few cases there are two societies from the one nation.

Last November the AAPPS held a successful 'Women in Physics' workshop with 50 delegates from 10 countries. Cathy Foley represented Australian Physics. Although the position of women in physics across the region has improved significantly, there is still a lot to be done. Australia has a role to play as a leader and mentor to regional nations to help advance the status of women in the physical sciences.

A major topic of discussion at the Council meeting was how to strengthen the collaboration between physicists in Asia and Europe. Presently there is a reasonable balance between the North America–Europe and North America–Asia collaborations, but the Asia–Europe link is much weaker. The first Asia–Europe Physics Summit (ASEPS) was held in Tsukuba, Japan in March last year and there are plans for the second ASEPS meeting to be held in Warsaw in late October this year. I will report further on AAPPS activities in future issues when I receive information from the meeting.

Another recent event of note is 'Science Meets Parliament'. Once again the forces of nature conspired to make my attendance problematic. I managed to attend the first day, but had to leave early to get back to Hobart before the second ash cloud closed off travel again. I was partially successful reaching Melbourne, but was stuck there for a few days.

Science meets Parliament is an annual event organised by FASTS (the Federation of Australian Scientific and Technological Societies). It is an opportunity for scientists from member societies to meet with parliamentarians and to brief them on issues of importance in their field. The first day is devoted to training delegates in how to deal with politicians and political advisors. It ends with a dinner in the Great Hall of Parliament House with politicians, advisors and diplomats attending.

The second day started with a breakfast address by Prof. Margaret Sheil, CEO of the ARC, followed by meetings between delegates and parliamentarians throughout the day. There was also a National Press Club lunch where Prof. Ian Chubb, the new Australian Chief Scientist, gave the address which was televised live and well reported in the media. Finally, there was a cocktail party at Parliament House hosted by the Greens. The AIP had a number of members present though some were representing other organisations. This is an excellent opportunity for our members to develop networks with MPs. Early career researchers are particularly encouraged to attend in future.

During the meeting FASTS announced a change to its trading name. It is to be known as Science and Technology Australia. This is a title that the media and politicians will have less trouble remembering and one that is more easily branded in the market place.

Also launched was the 'Respect the Science' campaign, aimed at informing the public about how scientific knowledge is developed and reviewed before it becomes public. It stresses that published scientific material is not opinion, but rather a thoroughly tested and critiqued reporting mechanism. The hope is to redress the public view of scientific reporting that has arisen as a result of the global climate change debate. I recommend that you visit www.respectthescience.org.au and view the video that has been produced for the campaign. You are welcome to send your comments direct to Science and Technology Australia or to me for forwarding.

LETTER

Response to 'A Problem with Entanglement regarding Special Relativity'

Dear Editor,

Jack Higbie points out in a previous Letter [*AP* **47**(6), 154 (2010)] that one can avoid a confrontation between quantum collapse processes and relativistic covariance, by adopting a knowledge-based interpretation of quantum states. In such interpretations [1], the collapse of a quantum state due to a measurement refers only to the change in knowledge of a local observer, rather than to some physical effect that propagates instantaneously in some preferred reference frame.

I agree that knowledge-based interpretations have advantages, and are certainly supported by this argument. However, three points are worth emphasising: (1) such interpretations do not untie the conceptual knot of entanglement; (2) it is logically possible to retain relativistic covariance in physical models of quantum collapse; and (3) whose knowledge are we talking about?

First, consider the statistics of highly entangled quantum systems. It is known that these statistics cannot be modelled unless at least one of three assumptions is relaxed:

(i) realism (predetermined measurement outcomes);
(ii) locality (physical effects limited by the speed of light); or
(iii) free will (freedom to choose between experimental settings).

Since Higbie's argument is based on avoiding nonlocal effects, he is therefore in the position of having to renounce realism and/or free will. In the first case, this leads to the difficulty of understanding the perfect correlations between observables of entangled systems arise – how can these correlations be guaranteed unless the outcomes are predetermined? In the second case, the system being measured must be allowed to have a statistical effect on the choice of measurement made by the experimenter [2]. Simply adopting a knowledge-based interpretation does not throw much light in this regard.

The second point to emphasise is that relativistic covariance does not logically require that a physical model of quantum collapse to be instantaneous in some preferred frame, as assumed by Higbie. For example, the collapse could instead be assumed to be along the invariant hypersurface defined by the backward light cone of the measurement apparatus, which all observers will agree on.

Finally, it is not entirely clear that 'knowledge' is sufficiently well-defined to underpin a physical theory. Consider the problem of 'Wigner's friend' [3] in a knowledge-based interpretation. The friend climbs into a box and performs a pre-agreed measurement on a quantum state. Is the friend now in a definite state of knowledge? Or in a superposition? The friend would presumably say yes. However, relative to Wigner the friend is merely in a superposition of states of knowledge – which Wigner could, in principle, cunningly time reverse so that no measurement or 'collapse' ever happened for his friend.

[1] Knowledge-based, or 'epistemic' interpretations of quantum mechanics date back at least to Schrödinger (see e.g. the translation of his famous 'cat paradox' paper at ts-si.org/files/Schrodinger-CatPPresentSituation.pdf), and have been more recently investigated by, for example, in Caves *et al.*, *Phys. Rev.* A **65**, 022305 (2002), and Spekkens, *Phys. Rev.* A **75**, 032110 (2007).

[2] A recent review of just what, and how much of it, must be given up to model entanglement, is at arxiv.org/abs/1102.4467 [see also the recent article by Tim Wetherell in this magazine: *AP* **47**(5), 119–20 (2010)].

[3] Wigner, 'Remarks on the mind-body question'. *In*: 'The Scientist Speculates: An Anthology of Partly-baked Ideas', (ed.) I. J. Good (Heinemann, London, 1961).

Michael Hall, Canberra, Australia

INTRODUCING OUR BOOK REVIEW EDITOR

John Macfarlane came to Australia from Scotland in 1964, having gained his PhD on thin-film dielectrics from the University of Glasgow. He was appointed to the CSIRO National Standards Laboratory as a Research Scientist, initially to work on the Hydrogen Maser frequency standard, and subsequently joined the Josephson voltage standard team when it was formed in 1969. In this project he developed a fascination with superconductivity and its applications, which eventually led to his appointment within CSIRO as a Project Leader in 1988–92, where he supervised the rapid progress in 'high-temperature' ceramic superconductors and extended his research on Josephson-effect devices to liquid nitrogen temperatures. He returned to Scotland in 1992 as a Visiting Professor at the University of Strathclyde, continuing his superconductivity research as well as teaching and supervision of PhD students. During 2000–06 he also held a visiting appointment at the National Physical Laboratory, Teddington. John is married with three grown-up children and five grandchildren. He finally retired in 2009, and has now settled in Northern Tasmania, where he is kept busy with his grandchildren, sailboats and vintage cars. Among his various AIP activities he is Book Review Editor for *Australian Physics* magazine.

The Australian Academy of Science has welcomed the decision to drop journal rankings [courtesy: AAS].

Academy welcomes decision to drop ERA journal rankings

The Australian Academy of Science had welcomed the decision by the government and the Australian Research Council to end the system of ranking academic journals as A*, A, B and C. The ranking system was a highly controversial component of the Excellence in Research for Australia (ERA) assessment of university disciplines.

Science Minister Kim Carr announced in May that the rankings system will end, giving more authority to the panels that examine and assess research activities undertaken around Australian universities on a discipline-by-discipline basis.

AAS Secretary for Science Policy Professor Bob Williamson said the new approach is much more appropriate than bibliometric assessments of disciplines: "In our recent submission to the Australian Research Council, the Academy argued strongly that key areas such as interdisciplinary research and new research were seriously disadvantaged by journal ranking. This affected not only areas of science and technology, but also interactions between the sciences and the humanities."

According to Williamson, "It has been very distressing to see some universities using publications in highly ranked journals as the basis for funding, promotions, and even staff appointments. The ranking of a journal as A* does not mean every paper in it is first rate, and some very good papers may appear in smaller journals. People whose work is very relevant to Australian issues rather than internationally, and those in new fields or collaborating between several universities, have been particularly disadvantaged."

The Academy's submission to the Australian Research Council ERA consultation process earlier this year urged a move towards a peer-review system. "We welcomed most features of the ERA, and the announcement has removed the single biggest problem", Professor Williamson said. "The integrity of science relies upon this type of peer review. The Academy commends Minister Carr for recognising that this process also should be integral to assessing the quality of Australian research."

Cathy Foley and CSIRO team recognised by mineral industry

The Mineral Industry Operating Technique Award (MIOTA) for 2010 was presented to Dr Cathy Foley, CSIRO, at a ceremony held at the Wrest Point Casino, Hobart, in May 2011, by the Australasian Institute of Mining and Metallurgy.

Cathy's CSIRO team was also represented at the awards dinner by John Macfarlane, Keith Leslie and Rex Binks. The award recognises the invention of a method to make a highly sensitive magnetic field sensor using a high-temperature superconductor. The sensor is the basis of the minerals exploration tool LANDTEM™,

John Macfarlane, Cathy Foley, Keith Leslie and Rex Binks at the Australian Institute of Mining and Metallurgy awards in May [courtesy: Island 26 Photography].

which has the ability to differentiate a desired ore body from other conductive materials, eliminating much of the need for exploratory drilling.

Over the period 1996–2007 Dr Foley led the initial development and commercialisation of the technique in collaboration with BHP Billiton and the then Canadian mining company Falconbridge. LANDTEM™ has since been licensed to an Australian start-up company Outer-Rim Development under the current CSIRO project leader Keith Leslie, and has ultimately helped to unearth an estimated $6 billion worth of new mines around the world. John Macfarlane was project leader during the early research phase in the late 1980s, while Rex Binks and his technical colleagues provided exceptional contributions to the mechanical and cryogenic aspects throughout the entire period.

Cathy Foley first joined the CSIRO Superconducting Devices group in the 1980s and has contributed to research into the non-destructive evaluation of metals for quality assurance in manufacturing, electrode-less heart monitors, remote detection of contraband at airports, terahertz imaging, submarine and UXO detection, and quantum computing.

Cathy was recently appointed Chief of CSIRO Materials Science and Engineering (CMSE), currently the largest CSIRO division which has two sites at Lindfield, NSW and Clayton, Victoria. She is a past-President of the AIP, and is well known for her strong promotion of science education, the role of women in science, and science in the media. She was awarded an Australia Day Public Service Medal in 2003, the Eureka Prize for the promotion of science in 2003, and the Telstra Women's Business Award for innovation in 2009.

Cathy is the current President of the Federation of Australian Scientific and Technological Societies (FASTS), the peak body that represents close to 70,000 scientists, engineers and technologists.

Bragg Gold medallist Dr Adrian D'Alfonso.

Bragg Gold medal for 2011

Dr Adrian D'Alfonso from the School of Physics, University of Melbourne, has been awarded the 2011 Bragg Gold medal for his PhD thesis on 'Atomic resolution imaging in two and three dimensions'.

In his famous talk in 1959, 'Plenty of Room at the Bottom', Richard Feynman issued the challenge "Is there no way to make the electron microscope more powerful?". Adrian's thesis explored theoretical aspects of scanning transmission electron microscopy and the comparison of simulation with experiment. By showing quantitative agreement between theory and experiment for bright field imaging, he was able to address the topical problem of contrast mismatch between high-resolution transmission electron microscopy and theory. Two-dimensional atomic resolution chemical mapping using electron energy-loss spectroscopy was demonstrated, and an imaging theory for the extension to imaging in three dimensions using scanning confocal electron microscopy was devised.

The improved understanding of atomic resolution imaging techniques developed in this work goes a long way towards meeting Richard Feynman's challenge of making the electron microscope more powerful.

[A feature article on Adrian's research will appear later this year – Ed.]

ROCK STARS:
The Four Ages of Diamond

Deborah Smith

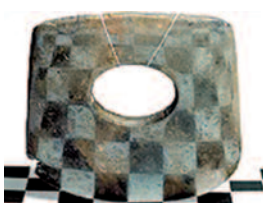
It was the highest price ever paid for a jewel. When a rare pink diamond fetched $46.8 million late last year, the sale almost doubled the previous record price, eclipsing a blue diamond sold in 2008 for $24.3 million. Since antiquity, the brilliance of the sparkling gems has made them the most coveted of stones and these recent purchases attest to their enduring allure.

The hardness of diamonds has also made them sought-after for more mundane applications, such as polishing, cutting and drilling. When those hoping to rescue trapped miners in the Pike River coalmine in New Zealand struck hard rock while drilling a shaft last month, they switched to a diamond drill. But diamonds have a very different, high-tech future in store, which goes far beyond their historical role as beautiful adornments or handy tools.

A physicist at the University of Melbourne, Dr Andy Greentree, says we are rapidly moving into the 'fourth age of diamonds', where some of the other unusual properties of this special form of carbon will be exploited by scientists in a wide range of areas, from medicine to computing.

Diamond is being used to develop bionic eyes for the blind, the next generation of extremely fast quantum computers and unhackable communication systems. Diamond lasers are also being developed that have the potential to treat skin diseases or detect dangerous substances such as explosives at airports. "Diamond is a wonderful material", Greentree says.

First age – from antiquity to the mid-20th century. Diamonds were found or mined and used for jewellery, decorations and polishing. Shown are two diamond polished axe-heads from China dated about 4500 and 5500 years old.



While diamonds are treasured here on Earth, on some other planets there could be oceans of liquified diamond, with solid diamonds floating in them like icebergs, recent research suggests. Neptune and Uranus have up to 10 per cent carbon and these giant gas planets have the ultra-high temperatures and pressures necessary for diamonds to exist.

Here, the temperatures and pressures that turn carbon into diamond naturally, with its unique crystal structure, are found deep underground. The glittering gems were forged millions of years ago at depths of up to 200 kilometres, before being brought near the surface in volcanic pipes. The first age of diamonds, when their usefulness and beauty were discovered, could have begun as far back as 6000 years ago. A study of four ceremonial stone burial axes found in the tombs of wealthy individuals in China suggests ancient artisans used diamonds to grind and polish them.

It was thought quartz had been used to smooth the axes, which are between 4500 and 6000 years old. But American researchers, led by Dr Peter Lu of Harvard University, used microscopic studies and other tests to show that only diamond could have achieved the mir-

Second age – from 1950 is characterised by the manufacture of cheap synthetic diamonds used for polishing and to drill rocks and teeth.

Third age – the present era where the manufacture of high purity synthetic diamonds is used in electronics and as scalpel blades. The third age has also seen the emergence of so-called 'blood' diamonds – the controversial gems that come from mines in Africa controlled by revolutionary groups who use diamonds to fund their operations.

"The recent breakthrough is the availability of batches of synthetic diamonds that are more or less identical." "If you want a really small, compact laser, you have got to get the heat out quickly and diamond is by far the best material."

ror-like lustre of the very hard stones. While this evidence for diamond use is circumstantial, it is clear that people in India had discovered diamonds in river gravel by 2500 years ago, pioneering a still-flourishing worldwide market for the hard and glamorous stones.

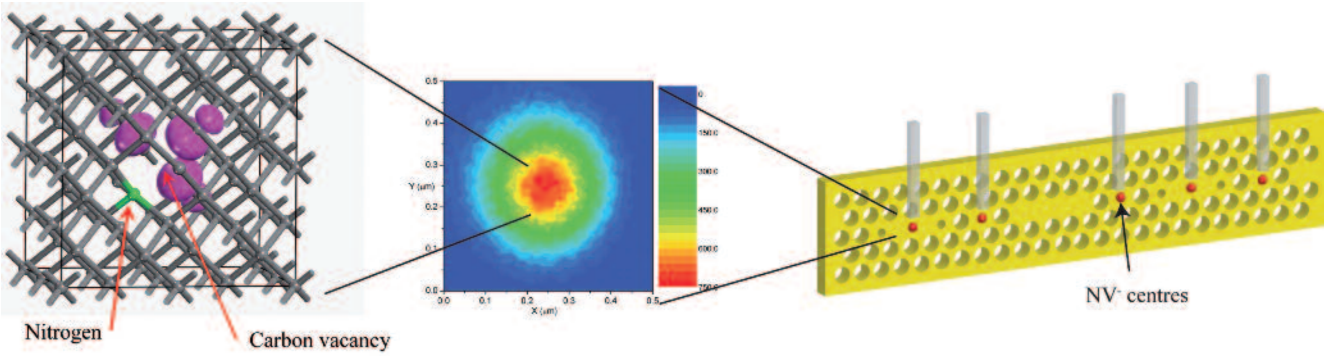
"The second age of diamonds began after World War II with the manufacture of synthetic diamonds", Greentree says. One technique is to emulate nature using high pressures and temperatures in an energy-intensive laboratory process. "It is quite expensive, although it is still cheaper than the market price of natural diamonds", Greentree says.

A less costly alternative is to cook up methane in a fancy microwave oven in a process called chemical vapour deposition, in which released carbon builds up as diamond on a surface. And nanodiamonds can be made by detonating explosives under the right conditions. While the word 'synthetic' makes them sound fake, synthetic diamonds are identical to natural diamonds, just man-made. And synthetic diamonds have many uses, including to drill into rocks and teeth.

"We are now in the third age of diamonds", Greentree says. Access to high-quality synthetic diamonds has expanded their use into electronics, optics and as refined cutting materials, such as scalpel blades. But the fourth age, where scientists can not only exploit, but also manipulate the properties of diamonds, is about to begin. "The recent breakthrough is the availability of batches of synthetic diamonds that are more or less identical", Greentree says. "When you dig diamonds out of the ground, every diamond is different."

Associate professor Richard Mildren of Macquarie University and his colleagues used some of these new, very pure, reproducible, man-made diamonds about eight millimetres long to develop the world's first diamond laser in 2008. Diamond conducts heat faster than any other material, which means they make small lasers of unprecedented power possible by drawing away waste heat. "If you want a really small, compact laser, you have got to get the heat out quickly and diamond is by far the best material", Mildren says.

Diamonds are not only the most transparent material in the visible light range – which is why their clarity is renowned – they are also transparent at other wavelengths, such as in the ultraviolet and infrared regions. "So we can make lasers at almost any wavelength we like", Mildren says. One exciting possibility is to make a laser at a wavelength that would be absorbed by proteins specifically. It could then be used in neurosurgery, for example, to precisely carve away a tumour without



Fourth age – will arrive in the near future. In health, there will be diamond electrodes in the bionic eye, diamond coatings for prosthetics, and lasers to be used in neuron surgery to remove tumours. In communications, diamonds will be used in unhackable communication systems and to develop quantum computers. In defence, carbon lasers will be used to detect toxic gases and explosives.

affecting surrounding brain tissue.

Diamond lasers at different wavelengths could also be developed to detect vapour emitted by explosives at airports. "Similar detection methods are needed in the military for roadside bombs. The US recently began to invest heavily in developing very high-powered diamond lasers that could be used as weapons", Mildren says.

New techniques to carve diamond into the desired configurations have been developed. One is to bombard it with a beam of ions to break the diamond away at the atomic level. Another is to convert some of the diamond into graphite and then remove it, leaving the shaped diamond. "We can then sculpt any shape we want", Greentree says. In 2008 Greentree was part of a University of Melbourne team led by Professor Steven Prawer that made the world's smallest diamond ring – a tiny loop only 300 nanometres thick and five microns wide [1]. Making these tiny diamond structures allows researchers to manipulate light in new ways.

Another important advance has been to create 'colour centres'. One example is where a carbon atom in diamond is replaced with a nitrogen atom and the neighbouring carbon atom is also removed to leave a gap. By shining light on these colour centres, single photons are emitted one by one. This could lead to a range of new quantum mechanical technology, including ways to overcome eavesdropping when information is sent down optical fibres. The laws of quantum physics prevent a robber stealing a single photon and resending it without anyone knowing, a concept called quantum cryptography.

Prawer's team at Quantum Communications Victoria has developed single-photon devices from diamond that are being commercialised for incorporation into ultra-secure communication systems. The tiny diamonds doped with nitrogen look a very promising way to build computers of the future, which will be able to carry out enormous numbers of processes simultaneously. These diamond-based quantum computers would use the spin of an electron to store information.

Researchers led by associate professor James Rabeau at Macquarie University are also working on light emitting nano-diamonds about five nanometres wide. "An important application could be to attach these tiny beacons to proteins for medical imaging, so the movement of the proteins could be tracked in cells and tissues", Rabeau says.

As if all these unusual properties of diamonds weren't enough, the material is also biocompatible, which means it is not rejected by the body. "As far as we understand, it does less to the body than medical-grade silicon", Greentree says.

Diamonds will have an important role in the bionic eye being developed by Bionic Vision Australia with a $42 million federal government grant. Images captured by glasses worn by the blind person will be sent wirelessly to an implant in the retina at the back of the eye. "The signals will then be sent by a diamond electrode array to the optic nerve to create an image that the person can see", Prawer says, whose team is designing the electrode array. To prevent corrosion of the implanted chip by body fluids, it will also be encased in a biocompatible diamond block.

Deborah Smith is Science Editor for the *Sydney Morning Herald*. An earlier version of this article appeared in the *SMH* in December 2010.

Reference

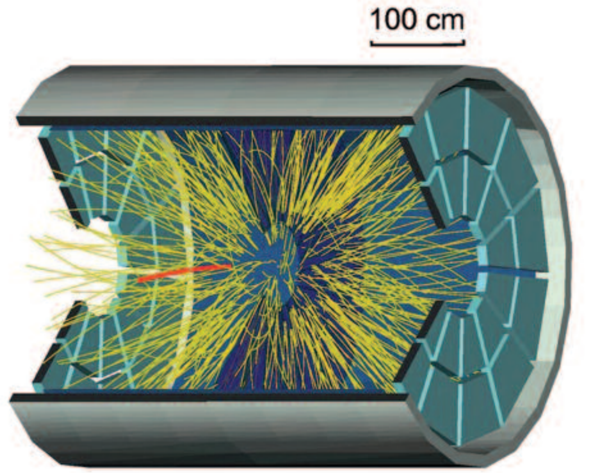
[1] S. Prawer and A. D. Greentree, 'Applied physics: Diamond for quantum computing', *Science* **320**, 1601–2 (2008).

Heaviest ever antimatter discovered

physicsworld.com/cws/article/news/45544

Physicists at the Relativistic Heavy Ion Collider (RHIC) in New York say they have created nuclei of antihelium-4 for the first time – the heaviest antimatter particles ever seen on Earth.

Antimatter nuclei are built from antiprotons and antineutrons but of all the various two- and three-quark combinations that can arise in particle collisions, it is rare that multiple antiprotons and antineutrons appear near enough to one another that they bind into anti-nuclei. Although the first antiprotons and antineutrons were discovered in the 1950s, the construction of heavier nuclei has been extremely taxing as each additional anti-nucleon makes the anti-nucleus 1000 times less likely to appear in a particle collision. Up until now, the largest anti-nuclei observed were capped at three anti-nucleons.



A 3D rendering of the STAR time projection chamber surrounded by the time-of-flight barrel shown as the outermost cylinder. Tracks from an event which contains a He-4 are shown, with the He-4 track highlighted in bold red.

But RHIC is an experiment that can generate the right conditions for the formation of antimatter by smashing gold ions together in an effort to simulate conditions shortly after the Big Bang.

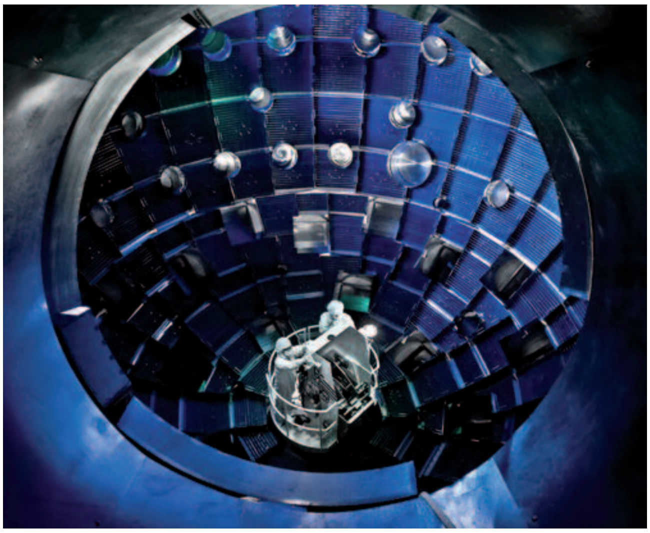
Laser heats up fusion quest

physicsworld.com/cws/article/news/45374

Physicists at the $3.5bn National Ignition Facility (NIF) say they have taken an important step in the bid to generate fusion energy using ultra-powerful lasers. By focusing NIF's 192 laser beams onto a tiny gold container, researchers have achieved the temperature and compression conditions that are needed for a self-sustaining fusion reaction – a milestone that they hope to pass next year.

Located at the Lawrence Livermore National Laboratory in California and officially opened last year, NIF will provide data for nuclear weapons testing as well as carry out fundamental research in astrophysics and plasma physics. The facility will also aim to fuse the hydrogen isotopes deuterium and tritium in order to demonstrate the feasibility of laser-based fusion for energy production.

These hydrogen isotopes will be contained within peppercorn-sized spheres of beryllium, which will be placed in the centre of an inch-long hollow gold cylinder – known as a hohlraum. By heating the inside of the hohlraum, NIF's laser beams will generate X-rays that cause the beryllium spheres to explode and, due to momentum conservation, the deuterium and tritium to rapidly compress. A shockwave from the explosion will then increase the temperature of the compressed matter to the point where the nuclei overcome their mutual repulsion and fuse.



Researchers at the US National Ignition Facility have taken a step closer to fusion by achieving the temperature and compression conditions needed for a self-sustaining reaction.

One of the main aims of NIF is to achieve 'ignition', which means that the fusion reactions generate enough heat to become self-sustaining. Researchers hope that by burning some 20–30% of the fuel inside each sphere the reactions will yield between 10 and 20 times as much energy as supplied by the lasers.

NIF first began testing the laser beams last year and now two groups at Lawrence Livermore have shown that they can obtain the desired conditions inside the hohlraum. They did this by using plastic spheres con-

taining helium, rather than actual fuel pellets, since these were easier to analyse, and by combining their experimental measurements with computer simulations, the researchers found that the hohlraum converted nearly 90% of the laser energy into X-rays and that it heated up to some 3.6 million degrees Celsius. They also found that the sphere was compressed very uniformly, its diameter shrinking from around two millimetres to about a tenth of a millimetre.

NIF head Edward Moses says that the next step will be to replace the plastic spheres with beryllium ones containing unequal quantities of deuterium and tritium, in order to study how hydrodynamic stabilities might lead to asymmetrical implosions. The final step will then be to switch over to actual fuel pellets, which will contain equal quantities of the two hydrogen isotopes, and which, it is hoped, will ignite. Moses says he hopes that ignition will take place in 2012. But he is keen not to raise expectations, having had to deal with many technical problems since construction started on NIF back in 1997. The work is described in *Phys. Rev. Lett.* **106**, 085003 (2011) and **106**, 085004 (2011).

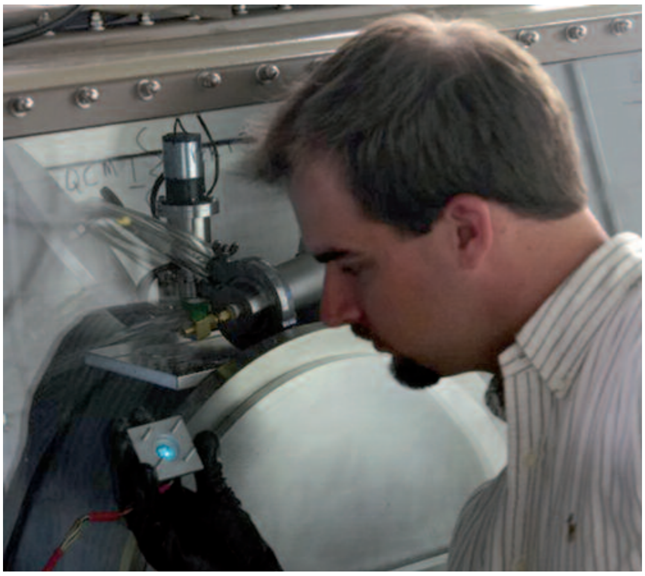
Organic transistor targets displays

physicsworld.com/cws/article/news/45891

Transistors using carbon nanotubes could have a big impact on the size and performance of television screens based on organic light-emitting diodes (OLEDs), according to a team of researchers in the US that has created red, green and blue pixels from transistors incorporating nanotubes and light emitting organic materials.

Displays based on OLEDs have shown great commercial promise because they offer high pixel brightness, wide viewing angle, a very high contrast ratio, fast response times and low power consumption. But display size is limited due to intrinsic non-uniformity in the polycrystalline-silicon backplane transistors of active matrix organic light-emitting diode displays – today's OLED TVs made by the likes of Sony and LG have screens just 28–38 cm across.

Now, Andrew Rinzler and colleagues at the University of Florida have built display pixels from light-emitting transistors using a technique that could be scaled to form large arrays of organic emitters. They have demonstrated an organic channel light-emitting transistor operating at low voltage, with low power dissipation, and high aperture ratio, in the three primary colours. The high level of per-



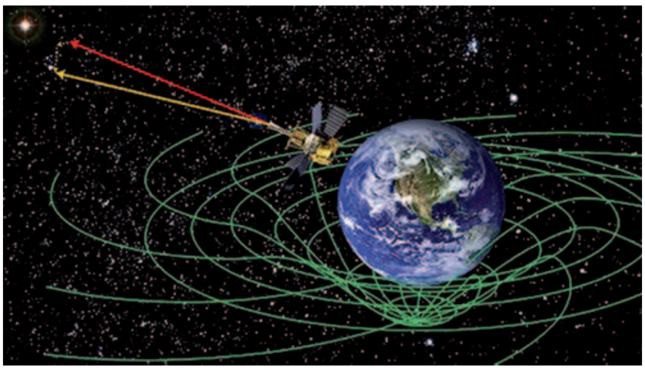
Bright light from less power: photo of an OLED blue pixel in the lab.

formance is enabled by a single-wall carbon nanotube network source electrode that permits integration of the drive transistor and the light emitter into an efficient single stacked device. The performance demonstrated is comparable to that of polycrystalline-silicon backplane transistor-driven display pixels. The work is reported in *Science* **332**, 570–3 (2011) (www.sciencemag.org/content/332/6029/570.full).

NASA announces results of epic space–time experiment

science.nasa.gov/science-news/science-at-nasa/2011/04may_epic/

Einstein was right again. There is a space–time vortex around Earth, and its shape precisely matches the predictions of Einstein's theory of gravity. This was confirmed with the announcement of the long-awaited results of Gravity Probe B (GP-B). "The space–time around Earth appears to be distorted just as general relativity predicts", says Stanford University physicist



Artist's concept of Gravity Probe B measuring the curved space–time around Earth.

Francis Everitt, principal investigator of the Gravity Probe B mission.

Time and space, according to Einstein's theories of relativity, are woven together, forming a four-dimensional fabric called 'space–time'. The mass of Earth dimples this fabric, much like a heavy person sitting in the middle of a trampoline. Gravity, says Einstein, is simply the motion of objects following the curvaceous lines of the dimple.

The point of the measurement was to confirm two predictions of general relativity. One is geodetic precession, in which the curvature of space–time around a massive object, such as Earth, induces a slight wobble in an orbiting gyroscope. Another, much smaller effect is gravito-electromagnetism, or frame-dragging, in which the spin of a massive object tugs space–time in the direction of its rotation, like a spoon twisted in honey. (For details see einstein.stanford.edu/SPACETIME/spacetime4.html).

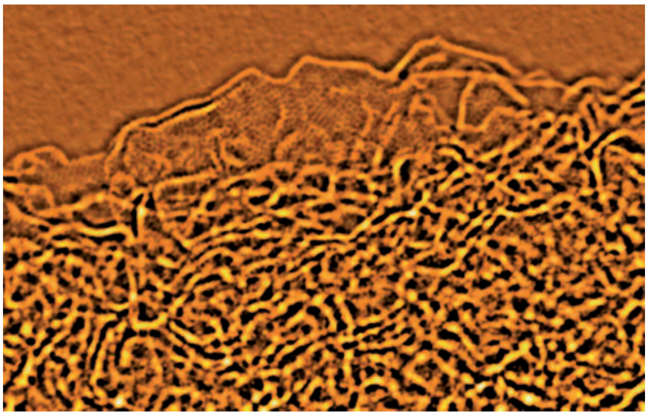
In practice, of course, the experiment is tremendously difficult, and a number of new technologies and highly precise measurements were needed to make the experiment possible. Now, after a year of data-taking and nearly five years of analysis, the GP-B scientists have measured a geodetic precession of 6.600 ± 0.017 arcseconds and a frame dragging effect of 0.039 ± 0.007 arcseconds, both values being in 'precise accord' with the predictions of Einstein's theory.

Clifford Will of Washington University in St Louis, who chairs an independent panel of the National Research Council set up by NASA in 1998 to monitor and review the results of Gravity Probe B, predicts that one day this will be written up in textbooks as one of the classic experiments in the history of physics. However, others have raised doubts about the value of the mission, mainly because the precision eventually achieved did not justify the huge cost of the mission – see *Nature* **473**, 131–2 (2011) (www.nature.com/news/2011/110511/full/473131a.html).

'Activated' graphite oxide boosts supercapacitors

physicsworld.com/cws/article/news/45976

Researchers in the US have discovered a new form of carbon produced by 'activating' expanded graphite oxide. The material is full of tiny nanometre-sized pores and contains highly curved atom-thick walls throughout its 3D structure. The team has also found that the material performs exceptionally well as an electrode material for supercapacitors, allowing such energy-storage devices to be used in a wider range of applications.



An atomic-resolution electron micrograph of the structure of activated graphene. The image shows that the material is composed of single sheets of crystalline carbon, which are highly curved to form a porous 3D network.

Supercapacitors, also known as electric double-layer capacitors or electrochemical capacitors, store more charge thanks to the double layer formed at an electrolyte–electrode interface when a voltage is applied. Although already used in applications such as mobile phones, these devices are currently limited by their relatively low energy storage density compared with batteries.

Now, Rodney Ruoff and colleagues at the University of Texas at Austin and scientists at the Brookhaven National Laboratory, the University of Texas at Dallas and QuantaChrome Instruments have synthesised a new form of porous carbon with a very high surface area (BET surface area ~3100 m^2/gm). The carbon consists of a continuous 3D porous network with single-atom-thick walls, with a significant fraction being 'negative curvature carbon' similar to inside-out buckyballs. The researchers used the material to make a two-electrode supercapacitor with high gravimetric densities of capacitance, energy capacity and power per unit mass. What is more, the team claims that the process used to make this form of carbon can be scaled up to produce industrial quantities of the material.

The work is published on-line in *Science Express* – see www.sciencemag.org/content/early/2011/05/11/science.1200770.

Don Price is with CSIRO's Division of Materials Science and Engineering at Linfield, NSW.

Swing Bowling

Why the Weather Matters

Jim McCaughan

The last Ashes Series of cricket held in England in 2009 revived a long-standing argument between scientists and players about the role of weather conditions in the ability of a bowler to impart swing – lateral movement in the air – to a cricket ball. The general consensus from scientists is that weather conditions play no role.

Typical opinions from scientists are that it is 'psychological'; it is 'folklore'; and it is a 'myth' [see refs 1, 2, 3]. According to Henderson [1]: "Science however has a different view of swing. Its causes have been well established by experiments that explode the myth that cloud cover and humidity have an effect."

To an experimental physicist and swing bowler of many years these denials are an embarrassment. To swing the ball depends on how the bowler delivers the ball, but given the appropriate delivery by the bowler, *weather conditions can greatly enhance swing or almost eliminate it.* Humidity however at best can have only a small effect [3].

Wind tunnel experiments have revealed the dynamics between air and ball surface that bowlers exploit to achieve swing, either 'in' (towards a batsman) or 'out' (away from a batsman), late or continuous [4]. The latter is colloquially referred to as a 'banana ball' – see Fig. 1. Wind tunnels have revealed that there are two regimes for late swing using an old ball, one that medium to fast–medium paced bowlers can use, the other called 'reverse swing', used by fast bowlers, where the swing is in the opposite direction to that at lower speeds. However, wind tunnel experiments [5, 6, 7] do not reproduce the variation in atmospheric pressure and the consequent dynamics that can exist in the open air.

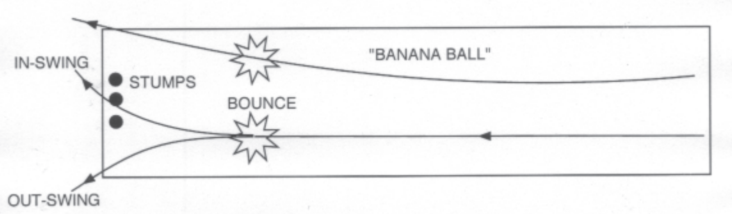


Fig. 1. Schematic of a cricket pitch with swing balls, with the 'banana ball' displaced for clarity.

Background on late swing with an old ball

To set the scene, Fig. 2 shows an old ball with both sides polished and seam in the direction of flight. The speed of the ball is such that the flow of air close to the ball surface, called the boundary layer, is turbulent. This enables the rest of the air to be drawn behind the ball before it detaches to form the turbulent wake (more later). The rest of the story concerns how changes, to ball surface through use, to the angle between the seam and the direction of flight and speed of delivery affect the behaviour of the ball through the behaviour of the air over its surface [8].

Fig. 3 shows an old ball in flight from right to left that is set to achieve in-swing to a right-handed batsman (as drawn in Fig. 1). One surface has been allowed to roughen with use the other has been kept polished by the bowler. The seam is angled in the direction of the intended late swing. The ball is delivered with backspin about a horizontal axis perpendicular

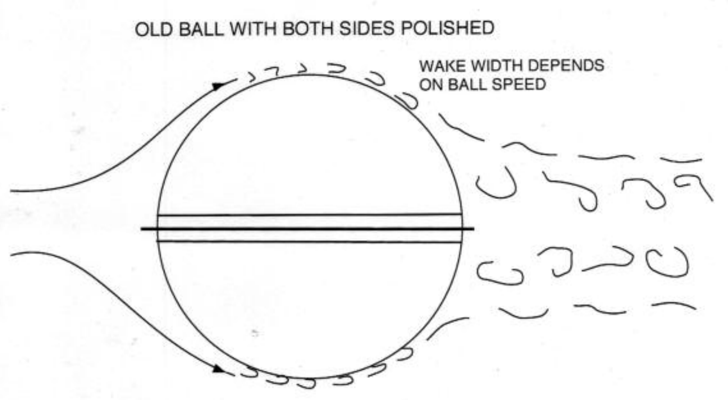


Fig. 2. Generation of the turbulent boundary layer and wake around a cricket ball.

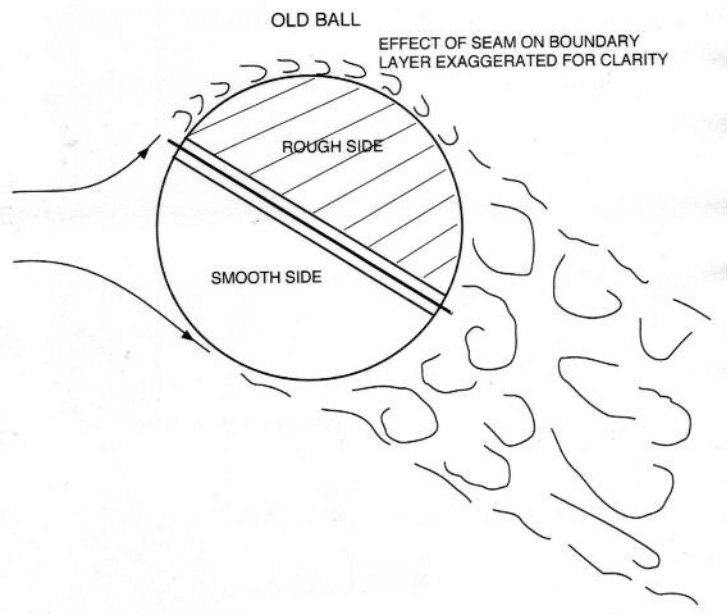


Fig. 3. Generation of in-swing around a cricket ball. Out-swing is the horizontal mirror image.

to the seam to stabilise the direction of the seam (eliminates tumbling) through free precession: Any disturbance of the spin axis is translated into a conical motion about the axis. Fig. 3 shows the behaviour of the air around the ball after the dynamics are triggered that cause the ball to move sideways (up the page as drawn) in addition to its forward motion.

Before the late swing dynamics are triggered, the air moves over the ball surface as in Fig. 2, except that the air that has passed over the leading edge of the asymmetric seam is thought to have a boundary layer thickened by the seam [6]. Fig. 3 shows this effect exaggerated. Otherwise both sides, rough and smooth, have turbulent boundary layers.

Usually the ball bounces a little distance in front of the batsman. There is a discontinuous drop in ball speed from the backspin skid. As the ball rises the speed of the airflow over the smooth side reduces to the critical Reynolds' number, whereupon the turbulent boundary layer switches to streamline. At once the air streaming over the boundary layer ceases to be drawn behind the ball before it detaches to form the turbulent wake. Meanwhile there has been no change to the airflow over the still turbulent boundary layer on the rough side, which continues to be drawn behind the ball, as the critical Reynolds' number is lower for the rough side. As a result there are asymmetric detachment points for the turbulent wake: from the side of the ball and behind the ball for the smooth and rough sides respectively as Fig. 3 shows. The turbulent wake gains in width and a sideways component of momentum [9].

Late swing and conservation of momentum

By conservation of momentum for the wake–ball system, if the wake goes one way the ball goes the other, as there is no sideways momentum before the detachment takes place and there is no other sideways force external to the system suddenly appearing. The swing is late because the switch from turbulent to streamline flow in the boundary layer on the smooth side is sudden and promptly causes the turbulent wake to switch to the side [10]. The greater the mass of air in the turbulent wake the greater the sideways momentum delivered to the ball. *The mass of air varies with the weather,* as it will be shown.

How turbulent boundary layer pulls air behind ball

When a slow bowler operates, the boundary layer on both sides of the ball is streamline, as the flow of air is below the respective critical Reynolds' number of each side. There is continuity in speed of the streamlines from ball surface, where it is zero, through the boundary layer up to the outer streamlines that move at the relative ball speed. When the boundary layer becomes turbulent, some of the translational kinetic energy is now stored as rotational kinetic energy in the turbulence [10]. *Hence once the boundary layer becomes turbulent it slows.*

Faster streamlines above now surf continuously into the boundary region. (Just like waves approaching the


[Credit: iStockphoto and Jarrod Boord]

seashore the water on top of the wave is travelling faster than the water beneath with the consequence that the water on top rolls over the water beneath to crash and slow on the shore.) This is the mechanism that pulls the streamlines around the trailing half of the ball surface, until the streamlines eventually breakaway only to be forced back by the pressure gradient, between atmospheric pressure and partial cavitation behind the ball, towards the receding ball to form vortices of the turbulent wake.

Late swing and pressure gradient

While an explanation via a conservation law is the most direct route to understand why the ball swings and that varying air mass can change the magnitude of the swing, the conservation law is a before and after statement that leaves the mechanism or the efficient cause of the swing unexamined, ie. the force that the air exerts on the ball and the ball on the air. When the ball moves through the air the leading face of the ball parts it into two streams (as seen in cross section). Like a constriction in a pipe the ball surface compresses streamlines and changes their momentum. There is a *local rise in pressure* from the compression that accelerates the air around the leading face of the ball. The increased flow in its turn reduces the pressure until at some point along the leading face the excess pressure turns into a pressure deficit; there is a Bernoulli trade off between pressure and kinetic energy [11].

While the turbulent boundary layer keeps these compressed streamlines attached to the curve of the ball surface the pressure deficit is maintained. It is when these lines separate from the guidance of the ball surface they decompress, slow and the pressure rises.

"Little attention has been paid over the years to the explanation of the swing of a new ball..."

The pressure gradient across the ball from the asymmetric detachment, higher pressure on the side that has detached and lower pressure on the side that the streamlines still follow the contour of the ball, gives the force of the air on the ball. It is obvious that the

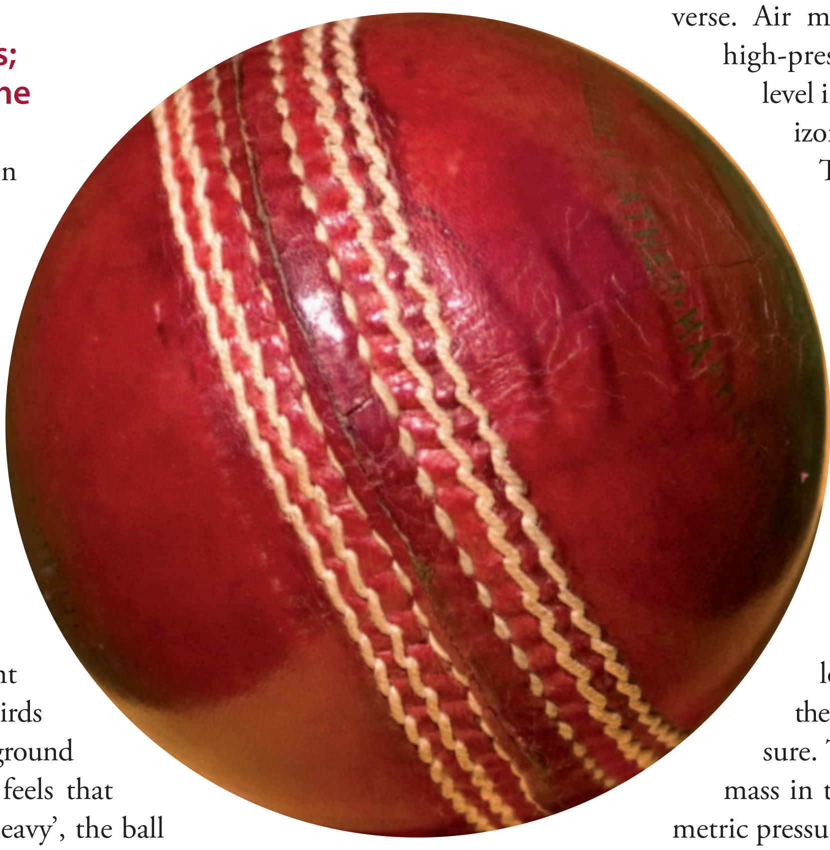
force of the ball on the air comes from the asymmetry of detachment. It will be shown that on low atmospheric pressure days, counter intuitively, there is a greater air density at ground level, so that for a given ball speed the kinetic energy in the boundary layer is greater and the corresponding pressure deficit greater (Bernoulli trade-off). This in turn results in a greater pressure gradient or sideways force across the ball [12].

Weather matters; evidence from the field

It is observed that on hot dry days the ball swings very little and then only in response to the greatest effort at back spinning the ball with the seam at a large angle to the direction of delivery [13]. But on days where rain accompanying a cold front is approaching, the birds are flying low to the ground after food and one feels that the atmosphere is 'heavy', the ball swings too much to trap the batsman with the normal amount of work on the ball. The luxury of fine-tuning the amount of swing is afforded by the latter weather conditions and the swag of wickets follows in the gathering gloom [13, 14].

Weather matters; evidence from the atmosphere

The cold front is associated with atmospheric low pressure; hot dry days with atmospheric high pressure. At ground level air from surrounding regions converges on the low-pressure region or cell that is in advance of the approaching cold front because of the horizontal pressure gradient set up. From there it pushes and spirals upwards and eventually flows away from the cell at higher altitudes [15, 16]. There is no net accumulation of mass in the cell and the barometric pressure remains low [ie. the total mass of air in the



cell is low]. But in order to acquire upwards movement an upward force is required. There is an existing negative pressure gradient that balances the weight of atmosphere in the cell; this cannot initiate vertical motion. The mass of air converging at ground level automatically increases the density of air establishing excess pressure at the base of the cell. [The mass at the *base* of the cell is high, but not the mass up the cell]. This is enough to initiate vertical motion. Dynamic equilibrium is established with the upward flow preventing a further mass accumulation or excess pressure. Backpressure from the pressure excess modifies the horizontal inflow, but the kinetic energy initiated up the cell is at the expense of the excess pressure at the base. There is a Bernoulli trade-off of pressure for kinetic energy [see above in the section 'Late swing and pressure gradient'].

On the hot dry days it is the reverse. Air moves away from the high-pressure cell at ground level in response to the horizontal pressure gradient. The loss of air mass reduces the air density and hence reduces the pressure at the base of the cell. This initiates downward air spiral from higher regions. Dynamic equilibrium is established with the downward flow preventing further mass loss and compensating the reduction in base pressure. There is no net loss of mass in the cell and the barometric pressure remains high.

Weather summary; ball swing measure of absolute local air density

Low barometric pressure responds to the statics of the situation, which is low air mass in the entire cell, but the dynamics requires high air density, hence high pressure, at ground level to give vertical motion up the cell. The high air density leads to large swing of the ball. High barometric pressure responding to the statics signals high air mass

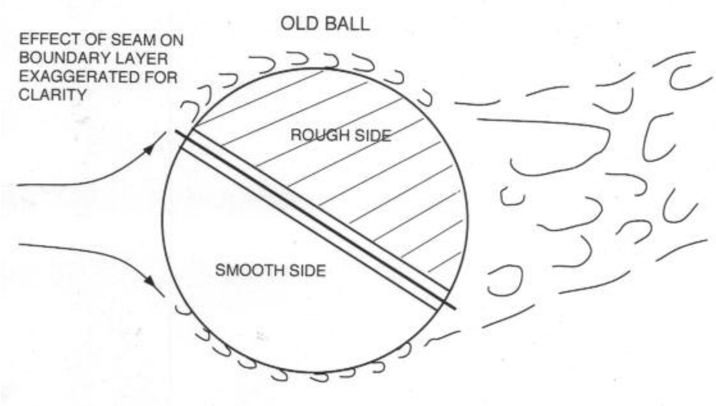


Fig. 4. Generation of reverse swing showing the effect of seam on the boundary layer.

in the entire cell, but the dynamics leads to low air density at ground level as air flows away from the cell. Low air density can only lead to small swing of the ball. *For a given amount of work on the delivery of the ball, the extent of ball swing is a measure of the local air density.* So that on low barometric pressure days the ground air density is absolutely high and on high barometric pressure days the ground air density is absolutely low. Needless to say, this atmospheric behaviour is not recreated in a wind tunnel.

New ball swing

Little attention has been paid over the years to the explanation of the swing of a new ball as far as I am aware. The new ball is coated with lacquer that gives the surfaces on both sides of the seam a very smooth finish. The new ball is usually bowled by a pace bowler so is quicker through the air and may travel well past the batsman before it swings. When it does swing it is greater for the new ball than the old and at times it reverse swings. Usually though the new ball swings conventionally and close to the batsman. Higher speed means higher pressure at the leading face of the ball from the compression. Higher pressure means the volume rate of flow loss to turbulence is greater [10]. The disparity in speed between the slow turbulent boundary layer and the free flow streamlines is greater. The mass from the streamlines surfing into the boundary layer is greater. The collapse of the streamlines around the ball is more extensive before they separate from the surface. With the width of the wake smaller for the new ball less drag ensues, hence its continued higher speed [17].

The speed of the ball ensures that the critical Reynolds' number is exceeded in the boundary layer, so that it is turbulent on both sides of the ball from the start of the delivery; the leading seam (closest to the front of the ball) makes some contribution to the turbulence. When the speed of the ball has dropped sufficiently to be below the critical Reynolds' number, the boundary layer turns streamline on the side of the trailing seam and the outer streamlines break away. There is an increase in the mass of air in the turbulent wake since the width of the wake has increased and is deflected to one side at a higher speed than for the old ball. Hence, the momentum transfer to the ball is greater and the swing of the new ball is greater than the old. Because the critical Reynolds' number is higher for a very smooth object, streamline boundary layer conditions set in at a higher ball speed [18]. At high ball speed the ball will swing conventionally (usually) when new, but reverse swing when old if delivered for swing.

Reverse swing

Wind-tunnel measurements of the detachment positions for the turbulent wake from an old ball with the leading side polished show at the highest Reynolds' number the detachment point on the smooth side to be much further behind the ball than at lower Reynolds' number [7]. At the same time, the detachment point on the rough side has retreated somewhat towards the front of the ball. The net result is a complete switch in direction of the turbulent wake from one side of the ball to the other at the highest Reynolds' number; see Fig. 4. The smooth side behaviour is similar to the new ball behaviour as discussed in the preceding section. The speed is sufficiently high on the smooth side that the boundary layer does not come out of turbulence.

Turbulence at this speed entails a greater mass surfing

"Little attention has been paid over the years to the explanation of the swing of a new ball..."

into the boundary layer from the outer streamlines and so is pulled with greater force behind the ball and hence detaches later. On the rough side the boundary layer encounters the seam early in its path. It is thought that the seam thickens the boundary layer [19] (Figs 3 and 4). If this opinion is correct then the boundary layer on the rough side pulls less mass from the streamlines into it than on the smooth side since the

"Much to my amazement and to the consternation of the batsman... the ball swung from side to side in the air with an amplitude of around 40 cm."

streamlines are further away from the ball surface. Then they are less pulled to the surface and break away sooner. The effect of the seam in thickening the boundary layer would explain the occasional reverse swing of the new ball in the previous section.

Academic cricket

I will finish with a story of what happened during a staff–student cricket match on St Paul's College oval at the University of Sydney in March 1971. The author was bowling into a very strong southerly wind coming from the direction of about first slip (from direction of out-swing in Fig. 1) to a right-handed batsman. The ball was eight, eight-ball overs old and had been carefully polished on one side. The ball was delivered for an in-swing. Much to my amazement and to the consternation of the batsman, Richard Thompson then a postgraduate student, the ball swung from side to side in the air with an amplitude of around 40 cm. Although the ball speed relative to the air was relatively high, relative to the ground it afforded Richard ample time to adjust his feet to cover the line of the ball. After several such oscillations as it approached the wicket it was veering towards slips as an out-swinger. Richard made one final adjustment of his feet across his stumps only to be bowled through the gap between bat and pad, as at the last gasp the trajectory turned into an in-swinger.

The difference on this occasion was that the ball was bowled into turbulent air. A wind tunnel experiment with turbulent air found significant negative (reverse swing) side forces could be induced even at small seam angles to the direction of flight [19].

Notes

[1] Mark Henderson, 'NASA scientist moves swing debate beyond the clouds', *The Weekend Australian*, 8 August 2009, p. 45. The NASA scientist quoted is Rabindra Mehta.

[2] Bob Crowder, 'The Wonders of the Weather' (Australian Bureau of Meteorology, Canberra, 1995), p. 101.

[3] C. B. Daish, 'The Physics of Ball Games' (English Universities Press, London, 1972), p. 2. The idea seems to be, as with [2], that the moisture displaces the air, but that seems to be more appropriate for immiscible liquids than gas or vapour where mixing is appropriate. The contribution to atmospheric pressure from 100% relative humidity at 30°C is 2%. There is no significant contribution to a 'heavy' atmosphere from water vapour.

[4] See note [3], p. 72.

[5] Rabi Mehta and David Wood, 'Aerodynamics of the cricket ball', *New Scientist* **87**, 442–7 (1980).

[6] Rabi Mehta, *Ann. Rev. Fluid Mech.* **17**, 151–89 (1985). This review incorporates data from many different authors – my thanks to A/Prof. Rod Cross for this and reference [7].

[7] C. Grant, A. Anderson and J. M. Anderson, 'Cricket ball swing – the Cooke–Lyttleton theory revisited', in 'The Engineering of Sport. Design and Development' (ed. S. J. Haake) (Blackwell Science, Oxford, 1998), pp. 371–8.

[8] See note [3], pp. 70–2.

[9] Norman Smith, 'Bernoulli and Newton in Fluid Mechanics', *The Phys. Teacher*, Nov. 1972, pp. 451–5.

[10] There is an experimental investigation of fluid flow through pipes in the first year physics laboratory at the University of Sydney. When the flow approaches the critical Reynolds' number there is a region of instability where the transition to turbulent flow is suddenly made only to lapse back to streamline. At higher flow rates the flow is permanently turbulent. In this region there is a reduction in the increase of volume rate of fluid flow with pressure increase. The missing translational energy goes to the rotational and there is not an increase in total kinetic energy as a result of turbulence as asserted in [5], p. 444.

[11] N. A. V. Piercy, 'Aerodynamics' (English Universities

Press, London, 1937), pp. 147–8. The variation in pressure around a symmetrical airfoil is analysed. The angle to the symmetry axis, measured from a point roughly corresponding to a radius, at which the pressure changes from excess to deficit, is 66.8°. Although the ball's circular cross section does not conform to the chosen airfoil cross section, some idea of how far around the ball surface the cross over point is reached might be indicated.

[12] Alan Grosvenor, painter of The Snowy Mountains, aeronautical engineer and yachtsman tells of other contexts for the ideas discussed so far: Putting sandpaper around the mast of a yacht to reduce its drag through the air; refusing to fly in a heavily loaded aircraft on a hot dry day. The lower air density and downward air flow reduces lift on the wings.

[Credit: Flickr/Jonathan Nalder, available under Creative Commons license]

[13] Fig. 9 of Mehta's review article [6] shows the dependence of the sideways force on seam angle, backspin and speed. The optimum delivery angle is 20°. There is some indication that at the highest end of all the measured values that a high sideways force is achieved in support of what actually happens in nature on hot dry days. On days of an approaching cold front, one can easily relax the conditions of delivery from the optimum by reducing the angle of the seam to the ball direction and reducing the amount of backspin.

[14] The author has seen Test great Alan Davidson bowl under these conditions from 'The Hill' of Sydney Cricket Ground. He was bowling from the Northern or Paddington end and from where we stood the ball appeared to be turning at right angles in the air as it reached the right-handed batsman as an out-swinger.

[15] See note [2], p. 110: 'The forced ascent of air resulting from convergence…'

[16] O. G. Sutton, 'The Challenge of the Atmosphere' (Hutchinson, London, 1962), p. 82: 'Air flows into the lower levels of a region in which pressure is falling, but it cannot accumulate there and is forced to ascend.' Neither Crowder [2] nor Sutton say how the force is provided.

[17] Note [3], p. 48. Whether old or new, the air pressure on the front of the ball in flight exceeds that at the rear when the wake is turbulent; this pressure gradient serves to slow the ball. Equivalently, the rotational energy in the turbulent wake is acquired at the expense of the translational energy of the ball.

[18] Note [3], p. 48. Streamline boundary layer conditions and breakaway set in at a higher speed for a new ball.

[19] Note [6], p.165.

ABOUT THE AUTHOR

Dr James B. McCaughan is an Honorary Senior Lecturer in Physics at the University of Sydney, where he still teaches. He retired in 1999 after 34 years on the permanent staff where he held a variety of positions, including Senior Lecturer (1987–99). His chief responsibility was running the first-year teaching labs. He spent 1962–63 at the University of Alberta as the Sydney representative in a joint experiment on the cosmic ray density spectrum at Banff. He has spent numerous study leaves at the University of Leeds. Jim is the author of a history of the Sydney School of Physics, *The Messel Era* (Pergamon, Sydney, 1987), and has published in the fields of cosmic radiation, physics education, history of physics, biography in physics, and the history and philosophy of science. He is presently working on the foundations of mechanics.

Giotto painted a New Picture of Comet Halley

Perry Vlahos

We appear to recall tragic occurrences more readily than their opposite number. As an example, most people remember 1986 for the Challenger disaster and the Russian Chernobyl nuclear power plant accident, but who can remember the other good stuff that occurred during the same 12 months? One that we should not forget was the outstanding success of the European Space Agency's *Giotto* spacecraft in its encounter with Comet Halley.

Europe's comet interceptor *Giotto* was launched in July 1985 on an Ariane 1 rocket from Korou, French Guiana. Giotto was the European Space Agency's first deep space mission. [Credit: European Space Agency]

The Greeks called them *kometes* – meaning 'long hair of the head', giving rise to our modern name, but not much was known about comets by the ancients. They could appear unexpectedly in any part of the sky. After reaching a peak brightness, in some cases with an ominous tail, they disappeared after some weeks, in a totally different part of the sky.

Soothsayers used them to predict the demise of kings and empires. To quote Shakespeare from his play *Julius Caesar*: "When beggars die there are no comets seen; the heavens themselves blaze forth the death of princes." In short, comets were seen as bad news and it was unknown whether they were inside or outside the earth's atmosphere, until the work of Danish astronomer Tycho Brahe in the late 1500s.

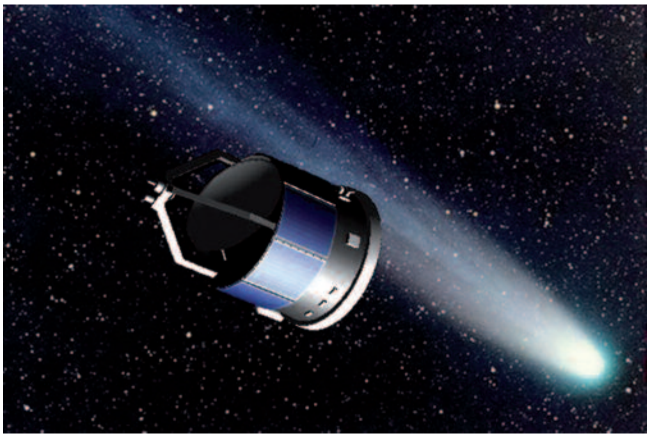
The invention of the telescope did not immediately shed more light on the true nature of comets, even though more physical detail could be seen, until Edmund Halley entered the picture. In November1680 a comet was seen heading toward the sun and became the brightest comet yet recorded. Weeks later, an equally impressive comet was seen moving away from the sun. It was thought that this second comet was a different one, but Halley suspected otherwise.

Around 1695, Halley used Newton's law of gravity to establish that, like the planets, some comets followed elliptical paths. Furthermore, he suggested that two comets seen in 1681–82 had very similar orbital elements to two previous comets seen earlier, about 76 years apart, in 1531 and 1607 and that they were one and the same. After working out the orbit, he predicted that it would return again in 1758. Halley eventually became the second Astronomer Royal, holding the position until his death in 1742, and so did not witness the comet's return.

Some properties of comets

In the ensuing years we have learnt that comets travel in paths resembling conic sections and that some of them are periodic, returning after a number of years. These are divided into short and long period comets; the former have an orbit of less than 200 years, whilst the latter can return after many thousands of years, in some instances millions if the eccentricity of their orbit is highly pronounced. Comet Encke has the shortest time-frame for a return, coming back every three years, whereas the best known comet – Halley – drops in to say hello once every 76 years.

Comet Halley captured in a 15 min exposure on 16 March 1986 from Murchison in Central Victoria by Astronomical Society of Victoria astrophotographer Mark Sansom. The best naked eye views of the comet could only be had by travelling to dark rural skies away from light polluted urban areas.

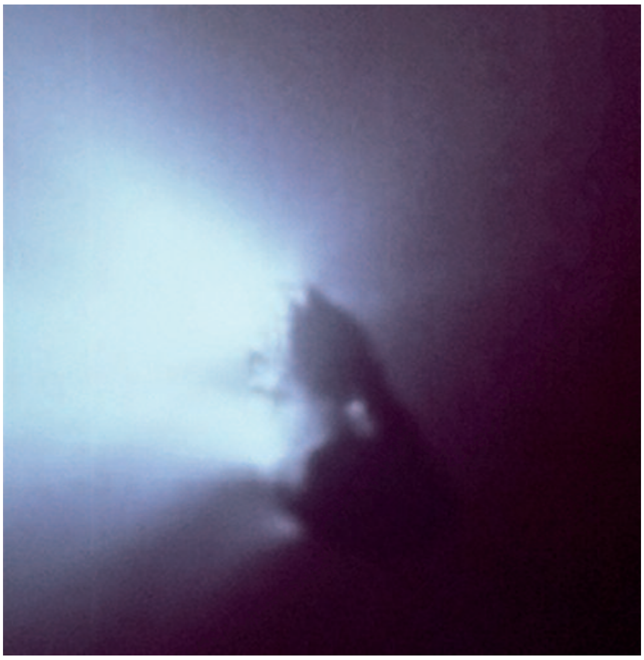


Artist's depiction of the *Giotto* spacecraft encounter with Comet Halley. The grey metallic shield at the front protected the delicate instruments long enough for them to acquire good images and other data, before transmitting them to earth.

A good example of a long-period orbit is Comet Kahoutek, last gracing our skies in the early 1970s and which will return in about 75,000 years. There is also a third group of comets that make a single journey to the inner solar system, where they are perturbed by the gravity of the gas giant planets, and are then ejected from the solar system never to be seen again.

During the mid-1800s an unexpected connection was made by Italian astronomer Giovanni Schiaparelli of Martian canals fame. He computed the orbit of the annual Perseid meteor shower and saw similarities with the orbital motion of Comet Swift–Tuttle. He correctly attributed the origin of this meteor shower to loose particles that had been shed by Swift–Tuttle and were left in its wake in orbit around the sun. Every year the earth would cross their orbit in August, sweeping up

Giotto di Bondone (1267–1337) painted his 'Adoration of the Magi' after he had seen Comet Halley in 1301. His depiction of the 'Star of Bethlehem' above the nativity scene, owes little to previous paintings, as it introduces a real celestial visitor – Comet Halley – into this religious scene [credit: Wikimedia Commons].



The historic image taken by *Giotto* of Comet Halley – the first ever view of the nucleus of a comet. Note the elongated peanut shape and the jets spewing out material that creates the comet's tail.

these small particles to create a meteor shower as they burned in the upper atmosphere.

Theories were also put forward to describe why some comets are short-period visitors and others long-period. Comets with short return visits are thought to originate in the Kuiper Belt – a disk of material roughly in the plane of the solar system that populates space beyond the orbit of Neptune. In contrast, comets with periods longer than two hundred years are from much further out.

"Comet Encke has the shortest time-frame for a return, coming back every three years, whereas the best known comet – Halley – drops in to say hello once every 76 years."

An idea now considered the most plausible was put forward by Dutch astronomer Jan Oort in the early 1950s. He suggested that a spherical cloud of comets encircles the solar system at a distance about one-third of the way out to the nearest star, Alpha Centauri, and that occasional collisions send them falling in toward the sun. Their orbits can be randomly inclined to the plane of the solar system and far from the 'ecliptic' – the path followed by the sun, our moon, and planets in the sky.

The 'gravel pile' model of comet structure, where comets were thought to be made up of loose piles of gravel or rock, coated with a little primordial ice, was about to take a hit. At about the same time that Oort published the cloud of comets idea, the American astronomer Fred Whipple put forward a proposal that, instead of the comets being mainly rock with little ice, they were the opposite – mainly ice with a little rock and dust. So the idea of comets being dirty snowballs became the accepted view. Even so, by the 1980s, there was still no clear idea of what the nucleus of a comet really looked like – telescopes could not see through the ice and dust that surrounded the head.

Welcome back Comet Halley

The appearance of new comets is unpredictable, but in the case of Comet Halley, its regular period of 76 years gave plenty of warning to prepare for its return. An in-

ternational armada of five spacecraft was readied to greet it, but the one to get in closest was *Giotto*. The spacecraft was named in honour of the famed Italian painter Giotto di Bondone who saw Halley's Comet in 1301 and then depicted it as the Star of Bethlehem in his 'Adoration of the Magi'.

Working from the late 1200s to early 1300s, Giotto was the first of a new breed of artists to give a different and more natural view of the world in his paintings. He broke away from the Byzantine style of a stiff and regimented depiction of the human form, and nature, that had held sway for centuries. He presented a truer and more natural representation with his brush, giving a viewer an almost three-dimensional picture to what existed before. It was indeed fitting that this shining light of the early Italian Renaissance was selected by the European Space Agency as the name for a spacecraft that was to deliver a thrilling first glimpse of the nucleus of this mountain-sized comet.

Originally, the *Giotto* spacecraft was to be partnered by a NASA probe in a joint mission but, unfortunately, American budget cuts resulted in the cancellation of this plan. Another plan was to have observational equipment onboard the Space Shuttle at the same time as *Giotto* encountered Comet Halley, but this was also abandoned after the Challenger Space Shuttle disaster. Consequently, the *Giotto* mission was eventually aligned with two Russian and two Japanese missions in an international effort. About the size of a small compact car and weighing 960 kg, *Giotto* was launched in early July 1985 from French Guiana to rendezvous with Halley on 13 March 1986. I can remember watching this close fly-by excitedly on live television in a school classroom with many students. The closest approach was 596 km.

Despite most particles coming from the comet being no larger than found in cigarette smoke, astronomers were concerned that larger particles, though much fewer in number, would make a direct hit on the spacecraft's most sensitive instruments and render the mission a failure. However, Fred Whipple came up with the idea of a shield comprised of two parts – a front element of thin aluminium, backed by a spaced second shield of thicker kevlar. The spacecraft was fitted with this 'dust' protector to increase its longevity and it took most of the 'bullets' fired from the nucleus. Unfortunately, the Halley multicolour camera took a direct hit and was disabled, but not before it sent back the first ever close-up images of a comet nucleus.

"The 'gravel pile' model of comet structure, where comets were thought to be made up of loose piles of gravel or rock, coated with a little primordial ice, was about to take a hit."

The pictures showed that the nucleus was peanut-shaped, about 15 km long and ranging from 7 to 10 km in width. It was blacker than tar with 10% of its surface actively spurting material out into space. Further analysis indicated that Halley is 4.5 billion years old, having formed about the same time as the earth.

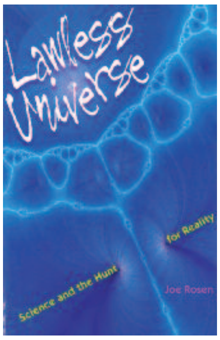
Let's celebrate the twenty-fifth anniversary of this wonderful success by *Giotto* and may it now have us linking 1986 with triumph, rather than disaster.

ABOUT THE AUTHOR

Perry Vlahos is an astronomy author, broadcaster and a columnist for Melbourne's *The Age* newspaper. He is immediate past president of the Astronomical Society of Victoria and currently holds the post of media liaison officer for the ASV. His astronomy column in *The Age* Green Guide can be read every Thursday.

BOOK REVIEWS

Compiled by John Macfarlane



Lawless Universe: Science and the Hunt for Reality

By Joe Rosen
Johns Hopkins Press, Baltimore, 2010, 200 pp.
ISBN 978-0-8018-9581-4
Reviewed by Joanna Turner, University of South Queensland

When I first picked up this book, I was intrigued by the title, imagining that the book would attempt to explain unusual but predicted phenomenon of the far-off distant universe. On perusal of the blurb on the back cover, I then imagined that this book would be an argument against such notions, and that theories such as those popularised by Stephen Hawking would be considered and analysed for their authenticity and ability to explain realities of which we had never seen.

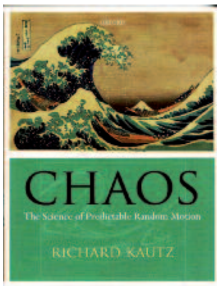
However, as I started reading, I realised that this book is really an essay in exploring (conceptually) what most people consider the be-all and end-all of truth (i.e. Science), and specifically how we understand and interpret what science means. It would be quite easy to say the book is almost a lesson on semantics. Indeed, I struggled through the discussion on objectivity and subjectivity at first, but having had some education in my undergraduate days on this topic, I found that Rosen's explanation to be relatively easy enough to grasp

For some reason, I still found myself thinking throughout the entire chapter, of the old adage: "If a tree falls when no one is around to hear it, does it make a sound?" Is the sound objective or subjective? Does having an observer change the essence of the sound being objective or subjective? The same applies to science itself. Rosen spends time laying out the details in logical order, presents the hypothesis and supports it with logical and sound reasoning.

So was this book what I thought it was going to be? Not really, but here is its narrative in a nutshell. Some people consider Science to be the truth, absolute truth and nothing but the truth. This of course can be misleading and, as most scientists would know, is subject to new information being discovered or made available or finding evidence to disprove a theory. There is, however, the search for a theory in which to explain 'everything', and as Rosen explains, there is no way to actually do this without taking science from the objective to the subjective. The result is then no longer science if it falls within the subjective category.

The idea of the 'Lawless Universe' comes from the concept that the Universe as a whole is unique (there is only one that we can be sure of). Observations about the Universe as a whole are unrepeatable, and as scientific reasoning dictates, repeatability is paramount in producing scientific explanations for observable phenomena. Therefore the Universe cannot have laws applied to it from a scientific sense; however, it can contain laws to explain reality within it. This book tells us that while science is a good thing in helping us to explain and understand the nature of reality around us, it also shows that taking science as an absolute, and therefore true, is wrong. My explanation perhaps is a bit crude, so do yourself a favour and read Rosen's account yourself.

I did enjoy this book on the whole, however I must point out exhaustion does not help in following the reasoning in this book. It simply is not bedtime reading. You need to be alert and ready to follow whatever path it takes you, and even being slightly tired meant that I lost track and could not keep reading. I recommend a nice coffee in the mornings with this book.



Chaos: The Science of Predictable Random Motion

By Richard Kautz
Oxford University Press, 2011, 368 pp.
ISBN (paperback) 978-0-19-959458-0
Reviewed by John Macfarlane, CSIRO Lindfield

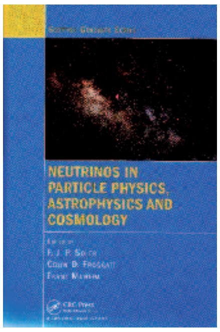
The motion of a simple pendulum, given its initial conditions, is precisely determined in theory by well-known dynamical equations. And so it is in practice, until it is driven beyond a certain limiting displacement, when its motion can suddenly become chaotic, even though the same equations still apply. This extreme sensitivity to the initial conditions is a hallmark of chaotic behaviour, as we see it throughout the natural world, whether in radioactive disintegration, economic crises, or weather prediction.

Richard Kautz had his first encounter with the disruptive effects of chaos while he was engaged in the development of a Josephson voltage standard at the (then) US National Bureau of Standards in the 1970s. It turns out that the electrodynamic equations for the behaviour of the superconducting Josephson junction are an exact mathematical analogue of the simple pendulum, and display analogous chaotic behaviour under certain conditions. After he and his colleagues had

worked out how to understand and control chaos in this highly specialised case, the subject became a lifelong study for him.

In this fascinating book he explores the myriad real-world situations where chaos may lurk, or indeed, play a dominant role. Using everyday examples ranging from fairground rides through cardiac arrhythmia to billiards, he maintains an interest in real-world, practical applications. A chapter headed 'Chaos makes noise', for example, elucidates a number of intriguing questions on how the human ear and brain effectively perform a Fourier (frequency) analysis to generate what we understand as music or harmony. He does not, however, hesitate to delve deeply into more mathematical topics such as strange attractors, fractals and Liapunov exponents.

This is much more than a textbook; wherever possible, Kautz has illuminated the subject with insightful biographical and historical snapshots of the 'giants' on whose shoulders he confidently stands. A useful, if concise, Index together with a wide-ranging bibliography, not to mention a free DVD with simulated experiments, mark this book out as a definitive work overall. Not a bedtime read by any means, but solid meat for many an afternoon's leisurely contemplation.



Neutrinos in Particle Physics, Astrophysics and Cosmology

Edited by F. J. P. Soler *et al.*
CRC Press, 2008, 386 pp.
ISBN 978-1-4200-8239-5
Reviewed by Lee Weissel, Wagga Christian College

A text is both challenging and fulfilling when the reader has to return to the archives of their memory to understand the material presented. This book is no exception and well worth the time to read, and in fact encourages further reading around the subject area in order to see the scope of such a work. Written primarily for graduate students and researchers in the field of neutrinos, it provides an up-to-date introduction to the topic of neutrino physics, astronomy and cosmology.

The material presented in the text is drawn from several leading international experts who presented lectures at the Scottish Universities summer schools in Physics. It covers all aspects of neutrino physics from the phenomenological and theoretical developments to future trends in cosmology. The material includes experimental data to support many of the findings which have led to our current understanding of the neutrino. The detection of neutrinos, and the collection of data, helps the novice understand this area of physics more precisely and assists in providing new areas of exploration.

The book commences with an explanation of the Standard Model of particle physics to build a context of understanding for all that follows. The nature of the neutrino with its relationship to other parts of the Standard Model is developed by other authors. There are discussions in relation to Big Bang cosmology, leptogenesis, neutrino astrophysics and solar neutrino physics.

The extrapolation of current experimental data from nuclear experiments has the feel of discovering a new country, with issues such as neutrino-less double beta decay and tritium decay. This leads to the reader seeing possibilities for our understanding of the neutrino and especially the possible role it may have in the baryon asymmetry of the Universe.

The editors must have worked hard to condense so much information into the text, and obviously worked with the various authors so that the reader can appreciate the growing body of information presented. Each chapter concludes with a summary which is very helpful. For those who may be initially intimidated by the mathematics, I recommend reading the summary first as it provides a framework for understanding the chapter as a whole.

The book can be read simply by the chapters of interest or all the way through. It is essential reading for those operating in the field of the Standard Model, and a very challenging read for those who are interested in what we currently know about the neutrino and the nature of reality.

[The book 'The Cold Wars: A Story of Superconductivity', reviewed in AP 47(5) (2011) 121, was previously reviewed by Professor Mukunda Das (ANU) in *The Australian Physicist* 41(3) (2004) 102 – Ed]

LASTEK

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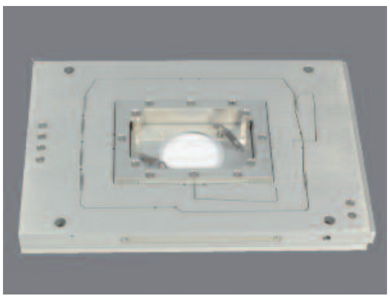

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Ocean Optics acquires Sandhouse Design

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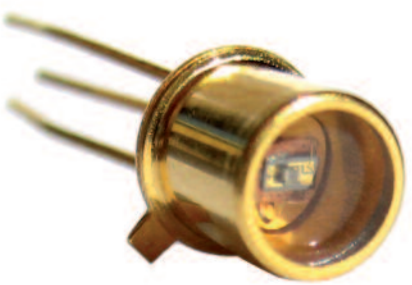

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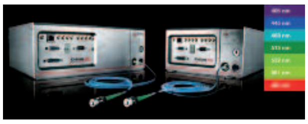

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- Most compact and cost effective solution for multicolour biophotonic applications

iChrome TVIS

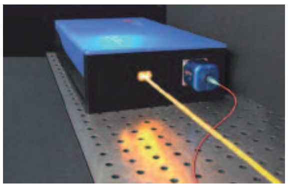
Our ultrachrome picosecond laser is:

- Continuously tunable in the visible range of 488–640 nm
- Fibre coupled output (single-mode)
- Fully automated operation
- Pure colour, narrow emission bandwidth (<3 nm)
- Perfectly suited for fluorescence lifetime imaging microscopy (FLIM) or optical testing of components

The iChrome TVIS laser system is a fibre laser with the flexibility to set automatically the laser output to any wavelength in the visible (488–640 nm). The coherent laser output ensures that the visible light exhibits the best intensity noise performance and the use of polarisation maintaining optical components a

stable linear polarisation of the fibre coupled output beam is achieved. The entire laser system is extremely user friendly: No alignment procedures of any optical components distract the user from the main task – to produce results.

DL-RFA-SHG pro 2 Watt @ 589 nm, single line for sodium cooling



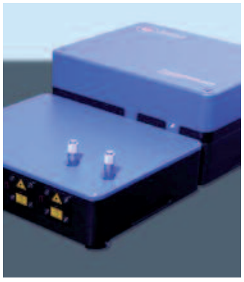
The new DL RFA SHG pro is a narrow-band tunable continuous wave laser for sodium cooling. The system is based on a near-IR diode laser in the successful 'pro-design' (DL 100/pro design, 1178 nm), with a subsequent Raman fibre amplifier (RFA) and a resonant frequency doubling stage (SHG pro).

The DL RFA SHG pro features a spectral linewidth below 1 MHz and 20 GHz mode-hop free tuning. For system operation, no water cooling and no external pump is required. The power scalable approach of the DL RFA SHG pro also offers solutions for other high power applications such as sodium LIDAR, medical therapy or super resolution microscopy. Customised systems with higher output powers up to 10 W are available on request. Wavelengths between 560 and 620 nm will soon be available as customised solutions.

FemtoFiber pro – the product family is expanded

After the successful introduction of the FemtoFiber pro IR, NIR and SCIR models, TOPTICA is now taking the final step to also include the remaining system variants such as tunable visible (TVIS), tunable near-infrared (TNIR) and tunable ultra compressed pulse (UCP). Options such as variable repetition rate (VAR) and a phase-locked loop Laser Repetition rate Control (LRC) by TOPTICA's well-established PLL-electronics are rounding up the FemtoFiber pro product family.

The first and fastest of the new models, UCP, shows short pulses in the range down to 13 fs, the fastest available on the market from a turnkey SAM modelocked fibre laser system.



The TVIS expands the super-continuum generation (SCIR) by a tunable second harmonic generation and allows transferring femtosecond pulse generation into the visible wavelength range from 490 to 700 nm.

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

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WARSASH

Lightweight Benchtop Vibration Isolation

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

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

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

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

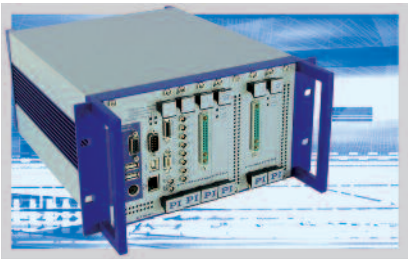
Self-levelling and active-air isolation give the platform low natural frequencies (1.75 Hz vertical, 2.0 Hz horizontal) and typical isolation efficiencies of 95% (vertical) and

92% (horizontal) at 10 Hz.

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

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

Real-Time Operating System for Systems Integration



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

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

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

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

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

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

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

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

E-618: 3.2 kW Peak Power for New Piezo Amplifier

Available from Warsash Scientific is the new PI (Physik Instrumente) E-618 high power amplifier for ultra-high dynamics operation of PICMA® piezo actuators.

The amplifier can output and sink a peak current of 20 A in the voltage range between -30 and +130 V. The high bandwidth of over 15 kHz makes it possible to exploit the dynamics of the PICMA® actuators. This type of performance is required in active vibration cancellation and fast valve actuation applications.

The E-618 also comes with a temperature sensor input to shut down the amplifier if the maximum allowed temperature of the piezo ceramics has been exceeded. This is a valuable safety feature given the extremely high power output.

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

For more information on these and the range of other PI products, contact sales@warsash.com.au.
Warsash Scientific Pty Ltd
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Web: www.warsash.com.au

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

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

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

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

The S-340 can be operated by the new, low-cost E-616 controller. Together, they form a compact, high-performance solution for beam control and image stabilisation as

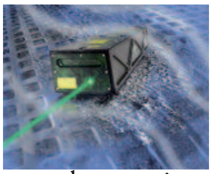
employed in astronomy, laser machining or optical metrology, for example.

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

COHERENT

Quantel release new dual-pulse later for PIV studies

Quantel has released EverGreen, a new dual-pulse Nd:YAG laser for PIV (particle imaging velocimetry) studies.



EverGreen incorporates dual laser cavities and common harmonic generation to produce two precisely overlapping beams. The lasers are integrated onto a common monoblock platform to guarantee perfect alignment and uniform light sheets. The power supplies and timing electronics are also integrated into a single housing. The EverGreen system requires no specialised installation and no adjustments of any kind. Pulse energies of 70 mJ, 145 mJ and 200 mJ are available. EverGreen is an ideal choice for a wide range of PIV applications and the simplified operation allows the researcher to concentrate on flowfield results rather than the laser.

For further information please contact Paul Wardill on sales@coherent.com.au.
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Brilliant Q-Switched Nd:YAG Lasers

The Brilliant laser from Quantel features a compact and reliable Nd:YAG oscillator of medium energy (up to 850 mJ at 1064 nm) with a full range of "plug and play" harmonic options (up to a 5th harmonic generator) as well as OPO's for tunable output. With over 1000 units installed worldwide, the Brilliant laser is a proven scientific workhorse offering exceptional stability, reliability and ease of use.

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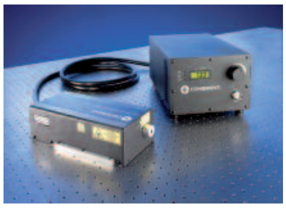
Verdi G Series expanded to 10 Watts of 532 nm output power



New! Photonics West announces release of the Coherent Verdi G10 DPSS-OPSL laser, the latest addition in the field-proven Verdi G product line with an output power of 10 W (532 nm CW). Featuring Coherent's next-generation of economical optically pumped semiconductor laser (OPSL) technology it offers a significantly smaller footprint, low-noise output and power-independent beam quality for higher power applications.

For further information please contact Paul Wardill on sales@coherent.com.au.
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CONFERENCES IN AUSTRALIA 2011–2012

19 – 22 July 2011
Fifteenth International Conference for Women Engineers and Scientists (ICWES15)
Adelaide Convention Centre, SA

12 – 13 August 2011
Summer School on Functional Imaging in Radiotherapy: Australasian College of Physical Scientists & Engineers in Medicine
Darwin, NT

14 – 18 August 2011
Engineering and Physical Sciences in Medicine and the Australian Biomedical Engineering Conference
Darwin Convention and Exhibition Centre, NT

28 August – 1 September 2011
IQEC/CLEO Pacific Rim 2011
Sydney, NSW

16 – 19 October 2011
Australian Radiation Protection Society Conference
Melbourne, VIC

31 January – 3 February 2012
Thirty-sixth Annual Condensed Matter & Materials Meeting
Charles Sturt University, Wagga Wagga, NSW

25 February 2012
Queensland Astronomy Education Conference (QAEC)
Brisbane, QLD

4 – 11 July 2012
Thirty-sixth International Conference on High Energy Physics, ICHEP2012
Melbourne Convention and Exhibition Centre, VIC

5 – 10 August 2012
Nuclei in the Cosmos 2012
Cairns Convention Centre, QLD

18 – 23 November 2012
Fifteenth International Conference on Small-angle Scattering, SAS 2012
Sydney, NSW

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Coherent Scientific

Quantel

High Performance Nd:YAG & Tuneable Lasers

Nanosecond Nd:YAG lasers

Dye lasers & solid state OPO's

Multipulse lasers

Coherent SCIENTIFIC

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