Australian Physics

Volume 49, Number 1, Jan–Feb 2012

Stockholm Diary – the 2011 Nobel Prize festivities

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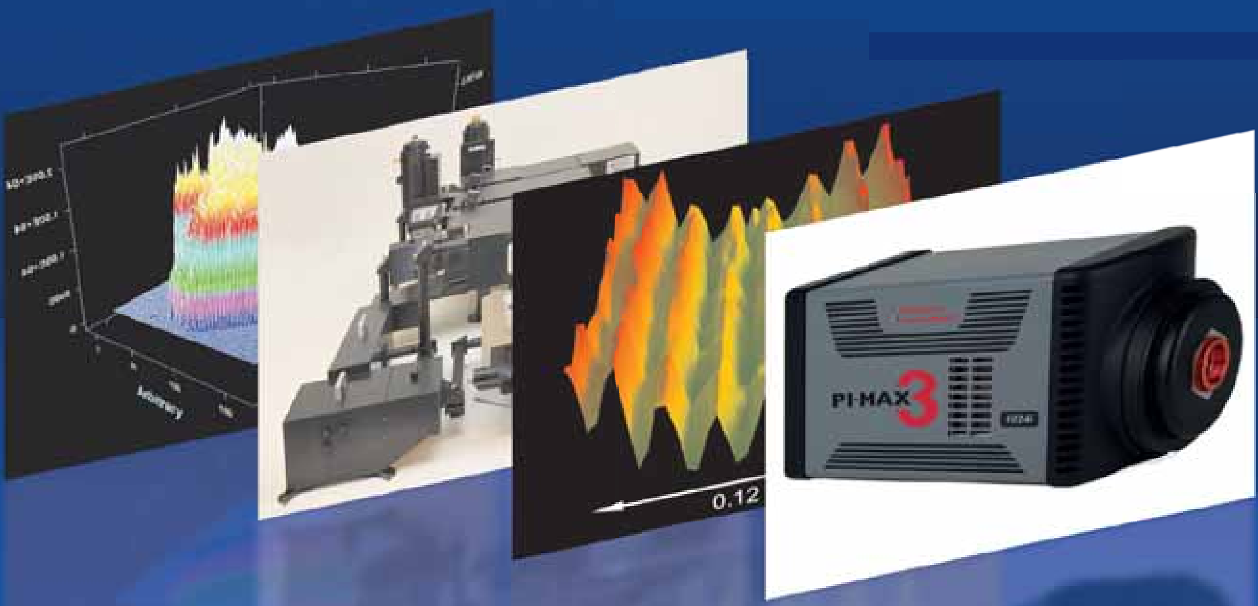

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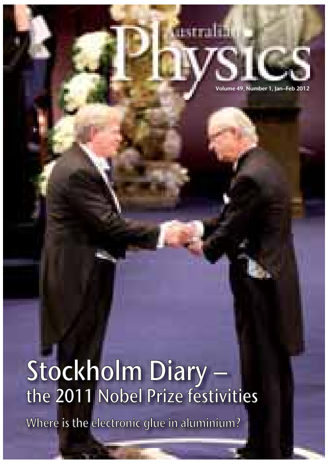

Cover

Professor Brian Schmidt receives his Nobel Prize Medal and Nobel Prize Diploma from King Carl Gustaf XVI of Sweden on 10 December 2011 – see page 11 [credit: Frida Westhom, Nobel Foundation].

Australian Institute of Physics

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

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EDITORIAL

How Swede it Is

The three astronomers who shared the Nobel Prize for Physics in 2011 have already blown a significant fraction of their prize money. The leader of the Supernova Cosmology Project team, Saul Perlmutter (University of California, Berkeley), paid the airfares to Stockholm for members of his team that carried out the prize winning work in the 1990s.

Australia's Brian Schmidt went one better and covered both travel costs and accommodation expenses at a swish hotel in Stockholm for about 15 members of his High-*Z* SN Search team. For his part, Adam Riess (Johns Hopkins University) presented each member of the High-*Z* team with a pair of gold cufflinks, inscribed with '$q_0 < 0$', the signature expression stating that the expansion of the Universe is accelerating.

There were three Australians – aside from Schmidt – who were invited along to enjoy the week-long festivities in December. In this issue we are delighted to publish the 'Stockholm Diary' of Professor Warrick Couch from Swinburne University. Warrick was not only a member of the Supernova Cosmology Project team, but also a driving force in its formation. It is interesting to read just how much is packed into a week which, for Sweden, must surely be the most important event in its international calendar.

Our second feature article in this issue is by Philip Nakashima (Monash University and ARC Centre for Design in Light Metals) who answers the question 'Where is the electronic glue in aluminium?' Pure aluminium is too soft and weak to be useful as a structural metal and it must be alloyed with small amounts of other metals to attain the stiffness and strength required for engineering applications. Philip was awarded the Barry Inglis Medal in 2011 for his research on measuring the atomic and electronic structure in materials by electron diffraction [see *AP* **48**, 170 (2011)].

Australian Physics magazine would like to take this opportunity to warmly congratulate three physicists who were awarded an AM (Member in the General Division) on Australia Day in January:

- **Hans Bachor** (ANU) for service in the field of quantum optics as a researcher and educator, and to the Australian Youth Science Forum [see *AP* **47**, 105 (2010)]
- **Rod Boswell** (ANU) for service in the field of plasma physics as an academic and researcher and through contributions to the international scientific community [see *AP* **48**, 136 (2011)]
- **Martin Green** (UNSW) for service as an academic and researcher, particularly through the development of photovoltaic solar cell technology, and to professional associations.

Peter Robertson

Call for comments on the Physics Decadal Plan

Welcome to a new year of Physics. And we do have a great year ahead. It will culminate in the AIP Biennial Congress to be held at the University of New South Wales in Sydney next December that will also be the launch of our fiftieth birthday.

I am preparing this column immediately following the AIP Council meeting at which the AIP National Office Bearers, Branch and Group Chairs and cognate society Presidents met to review the last year and plan for the year ahead. It was pleasing to see the extent and diversity of activities that the AIP achieves across the country. It was also pleasing to see that, after many years of membership decline, we have now had a few years of stability and even very modest growth.

Assoc. Prof. Bob Loss stood down as Registrar after five years on the AIP Executive. Bob has been a tremendous asset and we wish him well now that he has seen through a complete round of university physics course accreditations. The accreditations have become such a large task that we have appointed Assoc. Prof. Stephen Collins from Victoria University as the Accreditation Committee Chair removing this task from the Registrar portfolio. Dr John Humble has agreed to take over as Registrar for 12 months, looking after membership matters whilst continuing to take responsibility for the membership database and the development and launch of our new web site during the year. With John vacating one of the Special Project Officer positions on the Executive we have appointed Prof. Warrick Couch from Swinburne University in his place.

Immediately following the Council meeting the Decadal Plan for Physics Exposure Draft was released for public comment before finalisation. This plan was developed by a working group chaired by Prof. David Jamieson and under the auspices of the National Committee for Physics (NCP) of the Australian Academy of Science. It has been funded by the ARC and the AIP. The working group received electronic submissions, conducted one-on-one interviews and received feedback from the NCP and others in preparing the draft exposure. The report consists of two volumes: Part 1 is the Exposure Draft itself that provides a summary of the key findings and list of recommendations under the seven key areas for actions; Part 2 contains the background material. Most of the action areas have multiple activities listed (not included below) under each dot point to achieve their aims. The seven areas are:

Physics Education: supporting a physics enabled workforce and community

- Invigorate primary and secondary school physics education through raising the skill base in physics learning and teaching to best international standards
- Strengthen the quality and skills of Australian physics graduates and PhD graduates, measured against their international peers, by ensuring enhanced physics learning experiences and outcomes in higher education institutions
- Raise the national consciousness of physics, its value and its profile in the public eye

Physics Research Investment: increasing capacity, recruiting the best and brightest

- Increase the global competitiveness and impact of the Australian physics research sector

Physics in Industry

- Develop stronger relationships between the higher education and research sector with industry and business

Capturing the Full Human Potential

- Capture the full human potential in physics by providing clear career paths and enforcing equitable access to sustainable careers

The International Enterprise of Physics

- Make international research participation central to Australian physics

Physics in Collaboration with Other Disciplines

- Support the participation of physics in interdisciplinary consortia to address problems of national importance

Physics Productivity and Impact

- Increase research productivity by reducing administrative overhead and cost associated with managing the funding processes.

For the decadal plan to be effective it needs all physicists to read through it and to make constructive comments. You can influence the future of your discipline, so please send your comments to info@physicsdecadalplan.org.au. [A report on the progress of the Decadal Plan will appear in our next issue – Ed.]

Marc Duldig

Superluminal neutrinos from another dimension?

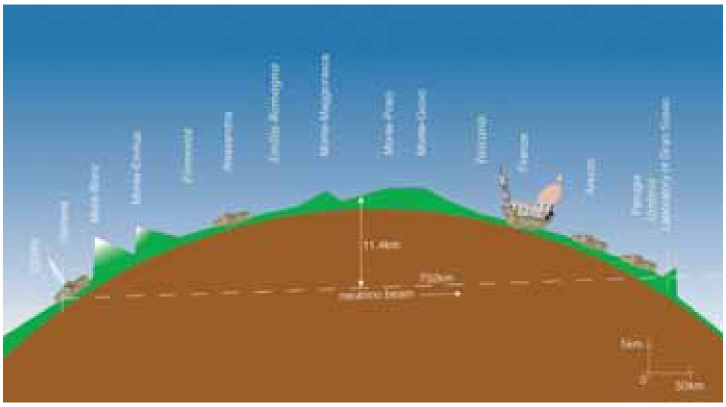
Dear Editor,

Recently the OPERA experiment at the Gran Sasso laboratory in Italy announced that it had measured neutrinos travelling faster than the speed of light. We, along with many others, thought that the experiment was in error and that a correction would soon be forthcoming. However, contrary to expectations, when the experiment was repeated with shorter neutrino pulses the conclusion was the same. The superluminal nature of neutrinos will not be accepted until a similar experiment is repeated elsewhere but, for the moment, we can no longer be sure that the speed of light is nature's speed limit.

The main concern with faster than light particles is that they are inconsistent with the primary postulate of relativity that the laws of physics are independent of the velocity of the observer. Mathematically this principle is summarised by the Lorentz transformations.

Before we take on the Herculean task of trying to reconcile the Lorentz transformations with the existence of superluminal neutrinos, we need to ensure that the results of the OPERA experiment have been analysed correctly. When measuring the speed of something in a rotating gravitational field, such as on Earth, it is not simply enough to divide the Euclidean distance travelled by the time taken to cover the distance. There are three relativistic effects that affect the measurement of the neutrino's velocity: the Sagnac effect, the geodesic equation and frame dragging. We will not describe each of these in detail, but we can point out that, even as a thought experiment, measuring the speed of neutrinos on the Earth is a non-trivial task.

If the experimental results are correct and the relativistic effects have been accurately accounted for (which we believe they have been), one proposal to explain superluminal neutrinos and keep the Lorentz transformations is to assume that the neutrinos are able to hop through dimensions of space that photons are not. The idea that neutrinos may take dimensional shortcuts is not as esoteric as it sounds. One of the fundamental tenets of relativity is that we may live on a hyper dimensional surface and be completely unaware of the existence of spaces beyond east, north and up; to paraphrase Gauss' theorem Egregium (Remarkable theorem) in a Rumsfeldesque manner – not only do we not know, but we cannot know if we are three (spatial) dimensional beings imbedded in a higher dimensional space. In 1921 Kasner showed that the Schwarzschild space–time can be represented as an imbedding of a four-dimensional surface in a six-dimensional space. Given this representation it is possible to compare the time of flight of a massless particle in Kasner space–time with one in Schwarzschild space–time. Our calculations show that the difference is in the sub-nanosecond level and therefore dimension 'hopping' cannot account for superluminal neutrinos.



Path of neutrinos from CERN to Gran Sasso.

It is fair to say that the majority of physicists believe that a systematic error will eventually be found in the OPERA experiment and that superluminal neutrinos will just be a flash in the pan. However, if their existence is confirmed, then those who believe that the Lorentz transformations cannot be violated will not even be able to turn to higher dimensions for help, at least in the simplest form of the Kasner metric.

Sam Drake and Alan Purvis
University of Durham, UK

In our next issue…

- Michael Murphy presents evidence that, on cosmic scales, the fine-structure constant is not actually constant
- Gordon Troup and colleagues clarify the concept of entanglement in special relativity and quantum mechanics
- Michael Biercuk describes how his group has developed a technique to detect tiny forces with a sensitivity over 1000 times greater than previous approaches

Bruce McKellar to lead IUPAP

The International Union of Pure and Applied Physics (IUPAP) at its General Assembly in November 2011, elected Professor Bruce McKellar as its President-Designate. When Bruce becomes President in 2014, he will be its first Australian, and indeed the first President from the Southern Hemisphere, of IUPAP.

IUPAP was formed in 1922 as an international organisation representing physics around the world, and Australia became a member in 1925. The mission of the Union is to assist in the worldwide development of physics, to foster international cooperation in physics, and to help in the application of physics toward solving problems of concern to humanity. The first President of IUPAP was Sir William Bragg, formerly of the University of Adelaide, so Bruce is not the first IUPAP President who was a professor of physics at an Australian university.

Today more than ever, physics is an international activity, with many of its problems being attacked by international collaborations of physicists. Australian physicists are making a significant impact on world physics through their participation in these collaborations and through their independent researches.

Professor Bruce McKellar [credit: Casamento Photography]

McKellar's election to this position recognises his contributions to physics, and his contributions to science internationally, and it also recognises the important role that Australian physicists are playing.

His PhD at the University of Sydney was on theoretical nuclear physics. During his time as a member of the Institute for Advanced Study in Princeton, he worked on two subjects at the interface between nuclear physics and particle physics, parity violation in nuclei and the constraints placed on three-body nuclear forces by results of particle physics. The work on parity violation, which effectively used the nucleus as a laboratory to study weak interactions, moved on to the study of CP violation, first through the electric dipole moment of the neutron, through to CP violation in hadronic systems, from particularly K-mesons and B-mesons. His interest in weak interactions led him to studies of neutrino oscillations, neutrino masses and mixing, and non-standard weak interactions.

While Bruce's work is now concentrated on particle physics, his research covers many aspects of physics and related subjects, and the journals in which he has published range from pure mathematics (a paper on solution of integral equations) to meteorology (papers on determining properties of the atmospheric aerosols by the way they scatter sunlight) to photographic engineering (a paper on the influence of grain size in a photographic emulsion on the image). His physics has covered atomic physics, solid state physics, statistical mechanics and mathematical physics, as well as nuclear and particle physics. This broad range of interests will serve him well in leading IUPAP.

Bruce is a Fellow of the Australian Institute of Physics, the Institute of Physics (UK), the American Physical Society, and the Australian Academy of Science. He has received the Boas Medal of the AIP, the Massey Medal of the IoP and the AIP, and the Pawsey, Lyle and Flinders Medals of the Australian Academy of Science.

The present President of IUPAP is Professor Cecilia Jarlskog, of Lund University, Sweden. Interestingly, Professor Masahisa Matsuda, now the President of Aichi University of Education in Japan spent one of his sabbatical years at Melbourne and another at Lund. As a result he has published papers with both Bruce and Cecilia.

Bruce is an Honorary Professorial Fellow of Melbourne University, and is an associate of the ARC Centre of Excellence for Particle Physics at the Terascale.

Michelle Simmons is NSW Scientist of the Year

Professor Michelle Simmons, who is the Director of the ARC Centre of Excellence for Quantum Computation and Communication Technology at the University of NSW, has been named NSW Scientist of the Year for 2011. The award has been made in recognition of her pioneering research on a radical technology for making electronic devices atom by atom in silicon. Her scientific vision has enabled the creation of the world's smallest precision transistor.

Simmons obtained her PhD from Durham University in 1992 and then spent six years at the Cavendish Laboratory in Cambridge. In 1999 she was awarded a QEII Fellowship and came to Australia where she was a founding member of the Centre of Excellence for Quantum Computer Technology at UNSW. She has established a large research group dedicated to the fabrication of atomic-scale devices in silicon using the atomic precision of a scanning tunnelling microscope.

Michelle said she was honoured to receive the award: "Ten years ago I moved to Sydney from Cambridge because I felt there was an opportunity to do some phenomenally exciting research here. It was the best move I ever made."

"Quantum computing is not easy science – it takes many different skill sets. Here at UNSW we have become international leaders in this field. There is noone else doing what we are doing and I am proud to lead this research effort. I'm pleased that this award will bring recognition to the work of the whole team, many of whom have been working on this project for years."

Simmons has three children under the age of eight. Speaking about the challenge of juggling a young family and a demanding science career, she said: "I think it's important for women to know they can have a family and a career. It's not easy, but it is possible and it's incredibly rewarding."

The ARC Centre for Quantum Computation and Communication Technology is an international research effort, funded by the Australian Research Council, the NSW State Government, the US Army Research Office and the Semiconductor Research Corporation and whose partners include the Department of Defence, IBM and Toshiba.

Michelle has published over 300 research papers and a book on Nanotechnology. In 2005 she was awarded the Pawsey Medal and in 2006 became the one of the youngest elected Fellows of the Australian Academy of Science.

Professor Michelle Simmons

Tweetup at Tidbinbilla

Shortly after NASA launched its new Mars mission last November, the Canberra Deep Space Communication Complex tracking station at Tidbinbilla near Canberra locked on to the signal from the spacecraft – and fifty-odd onlookers began tweeting to the world.

In the run-up to the launch the 'tweetup' group was given access to operational areas of the tracking station and met with a number of mission scientists, "people who've worked on landing sites for this mission, on sample returns from asteroids, and on Earth-orbiting

The Canberra Deep Space Communication Complex (CDSCC) at Tidbinbilla is one of NASA's three Deep Space Network stations. It is operated on behalf of NASA by CSIRO Astronomy and Space Sciences (CASS). [credit: Robert Kerton, CSIRO]

spacecraft", according to Glen Nagle, the CSIRO education and outreach manager at the station who organised the tweetup. "NASA has run tweetups since 2009 but this is the first such NASA-related activity in Australia."

Randomly selected, the 'tweeps' taking part include teachers, engineers, photographers, scientists and writers. They come from up and down eastern Australia and from as far afield as Oregon and California. What links them is their love of science and space exploration. The Canberra station and its counterparts in California and Spain will be NASA's lifeline to the spacecraft, sending commands and receiving data.

The Mars Science Laboratory will be the largest and most complex machine ever to land on Mars. A 900 kg robot and laboratory in one, it will scour the surface with high-definition cameras, examining the composition of soil with microscopes and spectrometers, even drilling into rocks and testing samples on the spot. It will search for signs of habitability and the ability of the planet to support life, now or in the past.

Much larger than the previous rovers 'Spirit' and 'Opportunity', the Mars Science Laboratory has been nicknamed 'Curiosity'. Unlike its predecessors it will carry its own power, in the form of a nuclear power pack. According to CDSCC operations manager Len Ricardo, "If the current rovers are anything to go by, we'll end up speaking to this robot for decades and it'll be travelling halfway around the surface of the planet. That would be a great thing."

Pawsey Medal awarded to Tanya Monro

Professor Tanya Monro of the University of Adelaide has won the prestigious Pawsey Medal for 2012. The medal – named in honour of the radio astronomer Dr Joe Pawsey – is awarded by the Australian Academy of Science and recognises outstanding research in physics by a scientist under the age of 40.

As Director of the Institute for Photonics & Advanced Sensing (IPAS) and the Centre of Expertise in Photonics (CoEP) at the University of Adelaide, Monro leads a team of academics, researchers, technicians and professional staff. She has made contributions of international significance to emerging areas of optical physics, most notably in the development of novel photonic, sensing and measurement technologies.

Professor Tanya Monro

The Pawsey Medal recognises a number of key achievements by Monro and her team, including: creating optical fibre cores that act as nanowires for sensing devices; creating the world's first surface-functionalised optical fibre 'dip sensor'; a new form of surface sensor that enables rapid virus detection; a new form of optical fibre that allows the fibre itself to be an active sensing material; setting the record for the world's smallest nonlinear fibre, nearly 6000 times smaller than conventional telecommunications fibres; creating porous fibres for transmission of terahertz radiation (T-rays); and encapsulating diamond nanoparticles in glass to create a hybrid material.

"Winning the Pawsey Medal is a great honour, and it reflects the excellence of the work being conducted in my research team in IPAS, from the discovery and demonstration of new physics through to driving disruptive new technologies for applications ranging from health to defence," Monro said.

"Ultimately, all experimental physics is about stretching the limits of measurement. Our work aims to create new measurement tools that will not only advance our understanding of light at the nanoscale, but also enable researchers in other fields of science to ask different questions."

Professor Monro was named the 2011 Scopus Young Researcher of the Year Award for Physical Sciences, and was South Australia's Australian of the Year for 2011 [see *AP* **47**(5), 102 (2010)].

Fig. 1. Brian Schmidt delivering his segment of the 2011 Nobel Lecture in Physics

Stockholm Diary

A Day by Day Account of the 2011 Nobel Prize Festivities

Warrick Couch

On the evening of 4 October 2011, it was announced that Brian Schmidt (ANU), Adam Riess (Johns Hopkins U) and Saul Perlmutter (UC Berkeley) were the joint winners of the 2011 Nobel Prize in Physics for their discovery that the expansion of the universe is accelerating. Not only was this wonderful news that a Nobel Prize had been awarded to an Australian, but it also represented the end of a 96 year 'drought' for it to happen in Physics – with the last Australian recipients being William and Lawrence Bragg in 1915.

In addition, there was a further Australian connection in that the Supernova Cosmology Project (SCP), led by Saul Perlmutter, had its origins in Australia as a result of a collaboration between the Anglo–Australian Observatory and UC Berkeley established by myself and Brian Boyle (CSIRO).

Both Saul and Brian (who was the leader of the other 'High-*Z* Supernova Search Project' team) were very generous in their recognition of their teams, inviting all members to join them in Stockholm for the award of the Nobel Prize and all the associated events and festivities. With this being a once in a lifetime opportunity, I accepted the invitation without any hesitation. Moreover, there was no leaving my wife behind for this trip! In what follows is a diary of my time spent in Stockholm for Nobel Week, where I have tried to record on a day-by-day basis both events and experiences of significance.

Day 1 – Arrival, Reception at Swedish Academy

We arrive in Stockholm at 10.30 am with a slight sprinkling of snow on the ground and the sun barely peering above the horizon. A shame Nobel chose to die in the cold and gloom of winter, not the warmer endless days of summer! After checking in at our hotel, it is a visit to The Grand Hotel – famous for it being where all the Nobel Laureates stay. Inside, within the imposing entrance hall and lobby of the hotel, there is the 'Nobel desk', where after parting company with many thousands of Swedish kronor, I am handed a big white envelope bulging with tickets, programs, and invitations for all events throughout Nobel Week.

The first formal event is a reception at the Royal Swedish Academy of Sciences in the evening. This Academy was founded in 1739, and we are reminded of its long history as we stand in the elegant gilt-edged reception rooms sipping wine and eating canapés, being looked down upon by the portraits of past presidents going back two centuries. A highlight of the evening is meeting Hans Nørgaard-Nielsen, with whom I collaborated back in the late 1980s in what was the very first distant supernova search. We reminisce about how we found just one supernova over three years of searching, but how important it was in inspiring the much larger SCP and High-*Z* searches that followed.

Day 2 – Nobel Lecture in Physics, team luncheon, Nobel Concert

An early start today, with the Nobel Lecture in Physics scheduled for a 9 am start at the University of Stockholm. This was to be the first of a number of 'Nobel' events held at this university. Interestingly, all four of the universities in Stockholm vie to participate in Nobel Week in this way, with it obviously being a wonderful opportunity for staff and students to rub shoulders with all the Nobel Laureates and their associates, and immerse themselves in all the festivities.

The Physics Lecture created an interesting challenge: how to partition it between the three Laureates? Weeks before arriving in Stockholm, Brian Schmidt had commented to me that this required extensive negotiations! The final 'tag team' arrangement has Brian going first, followed by Adam and then Saul, and all speaking for about 40 minutes. Brian gives a nice introduction by covering the historical context of what motivated the work that lead to the accelerating universe discovery, going back to Hubble's discovery of the expansion in 1929 – see Fig. 1.

Adam follows by giving a technical account of how the 'standard candle' property of Type Ia supernovae (SNIa) was used to infer the expansion history of the universe. Saul then focuses on the strategic, operational and logistical issues that the two distant SNIa projects (in particular the SCP) faced in amassing samples that were large enough to provide a definitive result. This includes some very interesting insights into the initial doubts and scepticism that both teams suffered over their 'accelerating universe' result. In what was a very generous gesture, Saul finished his segment by sequentially

Fig. 2. The three Nobel Laureates in Physics stand to receive their prize from the King of Sweden, while previous Laureates look on from the rows behind: Saul Perlmutter (left), Brian Schmidt and Adam Riess.

> **"Both Saul and Brian… were very generous in their recognition of their teams, inviting all members to join them in Stockholm for the award of the Nobel Prize and all the associated events and festivities."**

mentioning all the SCP team members, showing for each their photo and briefly outlining their contribution to the project. Overall, an entertaining and well-coordinated lecture!

Straight after the Nobel Lecture we catch a ferry out to the island of Fjäderholmarna where all the members of the SCP team gather for a celebratory traditional Swedish Christmas smorgasbord (julbord) lunch. The meal consists of seven courses eaten in the following order: raw herring, cold fish selection, cold meat selection (which included elk, reindeer, moose), salads, hot meats, special dishes, and the most evil desserts. This gourmet marathon plus the stunning water-side location and the perfectly sunny (but short) day made for a most memorable occasion.

The day finishes with the Nobel Prize Concert, held at the Stockholm Concert Hall where the Nobel Prize Award Ceremony will be held in two days time. With the Swedish Royal family (including the Queen) in attendance, we are treated to an inspiring and diverse range of music that includes some of the very well-known pieces and arias of Verdi, Puccini, and Saint-Saëns, performed by the world-renowned Maltese tenor, Joseph Calleja, accompanied by the Royal Stockholm Philharmonic Orchestra.

Day 3 – Lunch at Australian Embassy

The morning is free, so there is time to explore the inner city region of Stockholm where we are staying. Stockholm is very much a water-bound city, being spread across 14 closely located islands that are part of the Stockholm archipelago. This network of islands, linked by bridges and ferries, together with the many architecturally grand buildings, museums and palaces that are scattered across them, makes Stockholm a very beautiful and visually striking city.

The only official event today is lunch at the Australian Embassy, put on in Brian Schmidt's honour by the Ambassador of Australia, Paul Stephens. He and his wife make us feel very welcome and relaxed in their residence. Members from both the High-*Z* and SCP teams are in attendance, so it turns out to be a nice opportunity for us all to mix and catch up with each other.

The final appointment of the day is a visit to the formal suit hire shop to have my final fitting for the big events that are to follow over the next few days. The men's dress code for the formal Nobel events is tails, white tie, and black patent leather shoes which, we are told, is enforced very strictly! The only exception is that 'national costume' maybe worn instead, and here Brian Boyle did himself proud by wearing the full regalia of kilt, sporran, black brogues and so forth, of his native Scotland (see Fig. 5).

Day 4 – Nobel Awards Ceremony, Banquet, and Nightcap Ball

The big day has arrived, with the Nobel Award Ceremony, Banquet, and Nightcap Ball. We assemble at The Grand Hotel at 3 pm to take photos of us all in our best bib and tucker. Never before have I seen a bunch of astronomers looking so resplendent! Security at the Concert Hall is very tight, with us all having to show photo ID to gain entry. We find our seats are way up in the gods, but with

Fig. 3. Brian Schmidt receives his Prize from the King of Sweden.

a good front-on view of the stage. All the members of the other team are right next to us, so no favouritism there!

The ceremony gets underway with members of the Nobel Foundation, the Nobel Laureates, and the Swedish Royal Family (King, Queen, Crown Princess, and two Princes) processing onto the stage. The Opening Address is given by Dr Marcus Storch, the Chairman of the Board of the Nobel Foundation. Of note in his speech is acknowledgment of Prof. Steinman's death two days prior to the announcement that he was one of the winners of the Nobel Prize for Physiology or Medicine, as well as mention of the winners of the Nobel Peace Prize (three women) who were awarded the Prize in Oslo earlier in the day.

"Never before have I seen a bunch of astronomers looking so resplendent!"

It is then time for the presentation of the Nobel Prizes, with Physics going first (see Figs 2 and 3). The presentation of each prize is preceded by a short speech that explains the significance of the work for which the Prize is awarded. For Physics, this is given by Professor Olga Botner, who is a member of the Nobel Committee for Physics and was the one who announced the winners to the press back in early October. She starts her speech in English, with a quote from the Danish scientist and poet Piet Hein: "The Universe may be as big as they say, but it wouldn't be missed if it didn't exist!".

The rest is delivered in Swedish. Fortunately we have been issued with small booklets giving the English translation. Saul, Brian and Adam then stand, with each in turn having to walk to the centre of the stage to receive their prize (gold medal plus diploma – the prize money is paid a few days later) from the King of Sweden, and then stepping back and bowing to him, then the members of the Nobel Foundation, and then the audience. This part of the ceremony is renowned for things going wrong, with a number of Laureates having got the bowing sequence mixed up, and some having made additional 'victory' gestures to the audience – a complete no-no in front of the Royal Family! But all three put in a flawless performance.

The same routine follows for the other Prizes: Chemistry, Physiology/Medicine, Literature, and Economic Sciences. The applause for the winner of the Literature Prize, Tomas Tranströmer, is almost deafening, which is not surprising given he is a Swede. Also a nice touch that Steinman's wife is present to receive the Physiology/Medicine Prize on his behalf, although she violates protocol by blowing a kiss to the audience.

With the Award Ceremony finished, we move en masse to City Hall for the Nobel Banquet. What a magnificent venue this is, with its vast ceremonial halls and distinctive red 'monk's' brick construction. The banquet is held in the huge courtyard-like Blue Hall, which seems ill-named given the red brick walls, whose colour is further enhanced by the pink lighting. It is also overlooked by a large balcony from which a grand set of stairs lead down to the main floor of the hall (Fig. 4). Here rows upon rows of tables – enough to seat 1300 people – are all immaculately set for the banquet.

Things begin with a grand procession into the hall of the Royal Family, the Nobel Laureates and their partners, plus other dignitaries. To a great fanfare produced by trumpets and the pipe organ (the biggest in Scandinavia), and escorted by university students in their distinctive yellow and blue sashes and white caps, they enter via the top balcony and then down the stairs to sit at a 'high' table located in the centre of the hall. Physics seems to be the favoured discipline, with Saul's wife entering on

the arm of the King, and Brian having the Crown Princess on his arm!

The food follows the same route into the hall, with all the waiters lining up on the top balcony prior to each course and marching down the stairs with platters held high above their heads. Each waiter covers about 5 km in executing this serving routine during the banquet. Despite there being 1300 mouths to feed, the menu and quality of the food is superb, equal to that of a high class restaurant. The key to success here is a trial dinner, where members of the Nobel Foundation taste a range of dishes and make the final selections for the banquet. Tonight it turns out to be lobster for entrée, guinea hen for main, and an amazing mandarin and white chocolate mousse dessert, washed down with very high quality champagne, pinot noir, and moscato.

There is continuous entertainment throughout the meal by way of music and cultural displays. This is followed by the Laureates' speeches, and Saul does the honours for Physics, being the oldest of the three. Not an easy job being perched halfway up the grand stairs with 1300 people below, plus a large television audience as well, but he does it with great aplomb (Fig. 4).

The banquet ends with the official party processing out of the hall via the grand stairs, with all the other guests following them in order to move up to the somewhat smaller but equally sumptuous Golden Hall for the post-banquet dance. However, all of us have tickets to the Nightcap Ball organised by the students at

Fig. 4. Guests at the Nobel Banquet, held in the Blue Hall of the Stockholm City Hall, listen to Saul Perlmutter deliver his speech on behalf of the Nobel Prize for Physics winners.

"Physics seems to be the favoured discipline, with Saul's wife entering on the arm of the King, and Brian having the Crown Princess on his arm!"

Stockholm University, and so we leave City Hall.

With an iPhone app being available for the Nightcap Ball, it promises to be well organised and rather sophisticated. We are not disappointed, with the students going to great efforts to decorate what are normally dull hallway and meeting areas within the university buildings. There is also a much greater emphasis on food and drink rather than music/dancing, with numerous stalls set up offering a diverse and eclectic range of finger food and alcoholic beverages. The highlight is the chocolate fountain! Unfortunately by 2 am we all start to flag badly, and after taking some more team photos (Fig. 5), we decide to call it quits for what had been the highlight day of Nobel Week.

Day 5 – Much needed 'rest' day

With no Nobel events scheduled today, we use it as an opportunity to visit some museums. Here, the *Vasa Museum* turns out to be a real highlight. It contains the perfectly restored wreckage of the massive Swedish warship, the *Vasa*, whose maiden voyage in 1628 lasted just 20 minutes before it sank (in Stockholm harbour). It was located and brought to the surface largely intact in 1961, and then after many years of restoration work, it was moved to its current location with the massive museum building built around it, although its giant masts still poke out through the top of the roof.

Day 6 – 'Behind the Scenes' colloquium and joint team dinner

With this being the last day most people will be in Stockholm, two events involving both teams have been organised. The first is a 'Behind the Scenes' colloquium held at Alba Nova, Stockholm University. The

Fig. 5. The three Australian members of the Supernova Cosmology Project, Brian Boyle, Chris Lidman and the author, with Saul Perlmutter (second from left) at the Nobel Nightcap Ball.

format is to have a series of short three-minute talks given by most members of both teams, that cover all phases of the two distant supernova searches. Although it is an opportunity for both teams to reminisce, the colloquium is mainly for the benefit of the staff and students of the university, and indeed they show great interest with the lecture theatre packed, with many people spilling into the aisles. Despite the very late and rather chaotic organisation of the program, the colloquium turns out to be amazingly cohesive and rich in amusing anecdotes. Personally, it was gratifying to have the opportunity to speak about how the SCP got started in Australia, and how the appearance of SN1987A played a crucial role in bringing me into contact with the supernova team at Berkeley.

We then adjourn to the Pippi Longstocking Museum (Junibacken) for a joint team dinner. This is a children's museum that showcases the work of the Swedish author, Astrid Lindgren, who wrote the Pippi Longstocking stories, and our Swedish hosts thought it would be a fun location for us all to get together. To get us in a 'fairytale' mood, upon arrival we are issued with glasses of sparkling wine and taken on a train ride through Lindgren story-land. The dinner is equally jolly, with some nice tributes paid to Saul, Brian and Adam and the success of both teams by various members.

Day 7 – St Lucia dinner

Being December 13, it is St Lucia's Day – which is celebrated seriously in Sweden – and the final event of Nobel Week is the St Lucia Dinner, yet again organised by the students at Stockholm University. St Lucia was a Sicilian saint who was adopted by Sweden as its patron saint of light in the 1700s. The traditional way of honouring her is via a procession of people dressed in white gowns with a red sash singing traditional Christmas songs, usually led by a female who portrays Lucia by wearing a crown of candles on her head. We encountered this ceremony several times while in Stockholm, but the one held at the St Lucia Dinner is definitely the best. It also turns out to be the most solemn moment of the dinner, with the rest of the occasion being rather riotous, with a random mixture of Swedish drinking songs (which we all have to sing!), whacky student skits, and tongue-in-cheek speeches (including one given by the Vice Chancellor of the University), making sure the week finishes with a bang!

Day 8 – Departure

Unfortunately the time has come to leave Stockholm. It has been a surreal week; not even in my wildest dreams had I ever imagined being associated with a Nobel Prize, let alone be in Stockholm to participate in Nobel Week! In addition to the whirlwind of events that involved, the beauty of Stockholm, meeting up again with members of both teams after many years, and experiencing the warm hospitality of the students of Stockholm University will leave indelible memories. My only remaining desire is to return to Stockholm in summer!

BIO

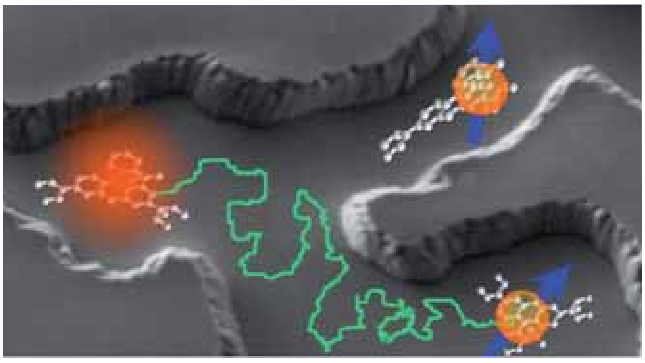
Warrick Couch is a Distinguished Professor and Director of the Centre for Astrophysics and Supercomputing at Swinburne University of Technology. He was born and educated in New Zealand, then moved to Australia to do his PhD in observational extragalactic astronomy at the ANU. He subsequently held positions at Durham University, the Anglo-Australian Observatory and UNSW, before taking up his current position at Swinburne in 2006. His interest in cosmology and galaxy evolution has seen him lead or play a key role in numerous major international projects, including the Supernova Cosmology Project, the Hubble Space Telescope 'Morphs' Project, the 2dF Galaxy Redshift Survey, and the Wiggle*Z* Dark Energy Survey. The significance of his research was recognised by his election as a Fellow of the Australian Academy of Science in 2009.

Ergodic theorem passes the test

For more than a century scientists have relied on the 'ergodic theorem' to explain diffusive processes such as the movement of molecules in a liquid. However, they had not been able to confirm experimentally a central tenet of the theorem – that the average of repeated measurements of the random motion of an individual molecule is the same as the random motion of the entire ensemble of those molecules. Now, however, researchers in Germany have measured both parameters in the same system – making them the first to confirm experimentally that the ergodic theorem applies to diffusion.

The experiments developed from the work of Christoph Bräuchle and a team at Ludwig–Maximilians University in Munich, who developed a technique for tracking individual dye molecules dissolved in alcohol that then pass through a nanoporous material. Such diffusion is of more than just academic interest because it plays an important role in a number of technologies, including molecular sieves, catalysis and drug delivery.

To confirm the ergodic theorem, Bräuchle's team tracked the molecules by illuminating the sample with light, making the molecules fluoresce. They were able to determine the position of a dye molecule to within about 5 nm. Individual molecules could then be followed as they moved through the sample by taking a series of snapshots. Meanwhile, a team led by Jörg Kärger at the University of Leipzig used an NMR technique to track the diffusion of all the dye molecules in a similar sample. The pulsed-field-gradient NMR method is sensitive only to the collective motion of all the dye molecules and cannot determine individual molecules. Comparing the results from the two groups showed that the average of many measurements of the diffusivity of individual dye molecules (as measured in Munich) was identical to the collective diffusivity of the dye molecules (as measured in Leipzig). Given that diffusion involves the random motions of molecules, the study therefore confirms the ergodic theorem.



This composite image illustrates both methods used to track dye molecules through the channels in the nanoporous material (grey background). Individual molecules (ball and stick figures) can be tracked using the light (orange glow) that they give off. Meanwhile, the collective motion of all the dye molecules is measured using NMR, which focuses on the magnetic moments (blue arrows) of the molecules.

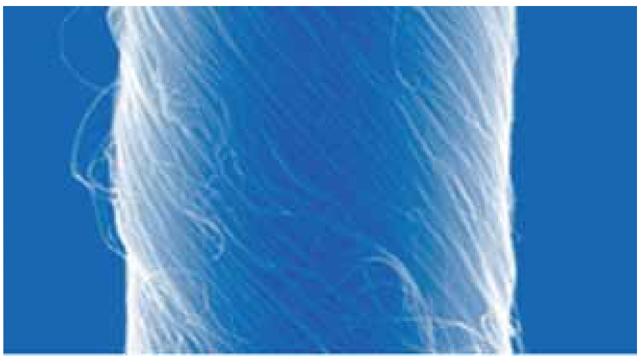
The work is published in *Angewandte Chemie International Edition* [doi: 10.1002/anie.201105388].

Nanotube muscles twist and turn

An international team of researchers, including a group from the University of Wollongong, has invented a new type of artificial muscle that is made from carbon-nanotube threads. The new structures differ from other artificial muscles in that they can twist and turn very quickly. The new threads could play an important role in technologies that require mechanical movement but where space is limited, such as in microfluidics, valves and robotics.

The muscles, made by a team led by Geoff Spinks (University of Wollongong) and Ray Baughman (University of Texas at Dallas) are composed of thin carbon-nanotube threads, or 'yarns'. Carbon nanotubes are themselves hollow cylinders of rolled up carbon sheets, which can be just one atom thick. The key to making the torsional structures is twisting the carbon nanotubes as they are made into a thread. The twisting produces a helical structure of intertwined carbon nanotubes.

Lengths of the nanotube thread are partially immersed then in an electrolyte, held firmly at each end, and one end is connected to a power supply such as a low-voltage battery. When the power is applied, the thread absorbs some of the liquid and swells. The pressure subsequently produced by the swelling causes the twisted structure to partially unwind, thus creating a rotating action similar to that seen when stretching a helical spring. The structure can be made to rotate in the opposite direction by decreasing the applied voltage.



A scanning-electron-micrograph image of a carbon-nanotube yarn with a diameter of 3.8 μm. The strands have been used to make torsional muscles.

The team found that they could produce rotations of about 250° per millimetre of thread length. This value is roughly 1000 times larger than those observed in previous torsional artificial-muscle systems that are based on ferroelectrics, shape-memory alloys or conducting organic polymers. And that is not all: the output power per unit mass of the yarn already rivals that of conventional electric motors.

The research is reported in *Science* [doi: 10.1126/science.1211220].

Do neutrinos move faster than the speed of light?

Can particles travel faster than the speed of light? Most physicists would say an emphatic 'no', invoking Einstein's special theory of relativity, which forbids superluminal travel. But now physicists working on the OPERA experiment in Italy may have found tantalising evidence that neutrinos can exceed the speed of light.

The OPERA team fires muon neutrinos from the Super Proton Synchrotron at CERN in Geneva a distance of 730 km under the Alps to a detector in Gran Sasso, Italy. The team studied more than 15,000 neutrino events and found that they indicate that the neutrinos travel at a velocity 20 parts per million above the speed of light. The principle of the measurement is simple – the physicists know the distance travelled and the time it takes, which gives the velocity. These parameters were measured using GPS, atomic clocks and other instruments, which gave the distance between source and detector to within 20 cm and the time to within 10 ns.

The OPERA detector

This is not the first time that a neutrino experiment has glimpsed superluminal speeds, but according to the OPERA researchers, their measurement of the neutrino velocity is 10 times better than previous neutrino accelerator experiments.

The discovery is described in arXiv:1109.4897. Not surprisingly the announcement has created a great deal of speculation and controversy. *Physics World* reports that a number of researchers in the OPERA collaboration feel that extra checks are required before the work is submitted to a peer-reviewed journal.

Slippery surface inspired by pitcher plant

If an unfortunate insect finds itself trapped inside a *Nepenthes* pitcher plant its chances of survival are pretty slim – these tube-shaped plants are lined with a slippery surface that causes victims to slide into a chamber filled with digestive juices. A group of researchers in the US has taken inspiration from these carnivorous plants to design a surface that is both slippery and highly repellent of external fluids. The scientists say their material would be cheap to produce in bulk and has a range of possible applications, including slippery pipes for the efficient transport of oil.

Nepenthes acquire their slipperiness from a thin lubricating film that lines the inside surface of these plants. These films are created when water or nectar becomes locked into microscale textures in the surface of the plant creating a continuous layer of lubrication. When the films come into contact with the oils on the feet of insects the friction is very low, making it difficult for these creatures to maintain their grip when attempting to climb out.

This technique for slipperiness used by *Nepenthes* has now been mimicked by Joanna Aizenberg and her colleagues at Harvard University who have created an 'omniphobic' surface that repels oils as well as water. Described as a 'slippery liquid-infused porous surface(s)', or SLIPS, the surface is fabricated out of a sponge-like material composed of a random network of nanofibres. The material was then coated in a lubricating film that is immiscible to a broad range of liquids. When a drop of complex fluid, such as crude oil or blood, was placed on the surface, it quickly slid off even if the surface was tilted only slightly.

The researchers say that one big advantage of the new material over alternative slippery surfaces in industry is its robustness. Materials based on the water-repelling properties of lotus leaves, for instance, rely on a layer of trapped air, which can become unstable at high pressures – leading to a poor performance or permanent damage.

The work is reported in *Nature* **477**, 443–7 (2011).

Where is the Electronic Glue in Aluminium?

Philip Nakashima

Pure aluminium is too soft and weak to be useful as a structural metal and it must be alloyed with small amounts of other metals to attain the stiffness and strength required for engineering applications. In general, the ratio of alloying elements to aluminium used in commercial alloy production is just a few percent, resulting in very small changes in density but many-fold increases in strength. The strengthening mechanism is the 'scaffolding' effect that small precipitate particles of a secondary phase have after they are formed during heat treatment of alloys. Some precipitate phases are more conducive to strengthening than others and these are the ones that should be promoted during industrial processing and production.

Introduction

Knowledge of the atomic structure of these precipitates is a pre-requisite to understanding their growth mechanisms and the conditions promoting their growth. The present work was in fact motivated by attempts to determine the atomic structure of the T_1 precipitate phase in aluminium–copper–lithium alloys, used in aerospace applications including the wing supports of the Airbus A380. (The arrangement of atoms within the T_1 phase has been the subject of considerable debate in the literature. A recent study using a different approach [1] has meanwhile determined the best candidate structure for T_1.)

The approach adopted here involved convergent beam electron diffraction (CBED) from a volume of alloy containing a single T_1 precipitate (see Fig. 1). The diffraction patterns contain information about the precipitate's atomic structure that is entangled in the electron scattering from the surrounding aluminium matrix. Therefore, to

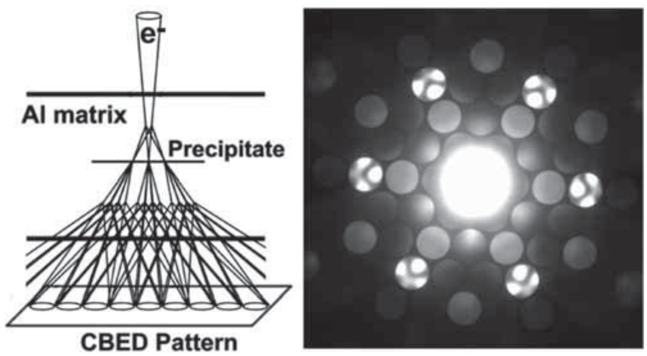


Fig. 1. At left is a schematic representation of how one might probe the structure of a strengthening precipitate (like T_1 found in aeroplane wing supports) with a focussed electron beam. An actual CBED pattern at right is produced where the information from the precipitate is heavily entangled with that from the matrix.

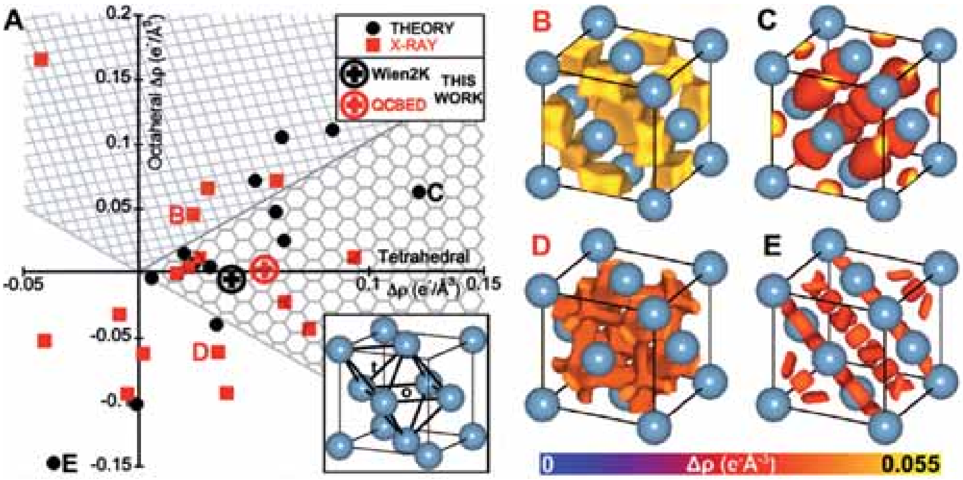


Fig. 2. Plot of bonding electron density in the octahedral versus tetrahedral holes in the fcc structure of aluminium ('o' and 't' in the inset respectively) for each published electron density study since 1929 [2]. The results of the present work are also plotted here for comparison. The cross-hatched region corresponds to dominantly octahedral bonding and hexagonal-hatching to tetrahedral bonding. Four examples from the literature are compared (points marked B–E in the plot correspond to each of the 3D plots at right). Iso-surfaces are plotted at bonding electron density levels that show the nature of the bond distributions. The legend shows the magnitude of the bonding electron densities. B and D correspond to two experimental determinations and C and E to two *ab initio* calculations [2].

Previous determinations of bonding electron density

Aluminium is one of the most widely studied metals in terms of its electron density distribution with about 30 independent experimental and theoretical studies published in the past 80 years or so [2]. It was therefore anticipated that a literature search would establish a very reliable and accurate knowledge of how atoms are bonded in pure aluminium. The opposite was true.

Fig. 2A summarises the spread of electron density determinations across the literature by plotting the results of each published study as a point on a graph of the bonding electron density in the octahedral hole $\Delta\rho_{oct}$ versus that in the tetrahedral hole $\Delta\rho_{tet}$. These two sites in the face centred cubic (fcc) structure of aluminium (marked 'o' and 't' respectively in the inset) are the most bonding-sensitive sites.

Four examples (points marked B–E in Fig. 2A) are illustrated by 3D plots of the bonding electron density $\Delta\rho$ in each of the unit cells making up Figs 2B–2E. Fig. 2B shows bonding to be octahedrally centred, while 2C suggests a mixture of tetrahedral and octahedral bonding. Fig. 2D shows transverse linear or 'bridge' bonds and 2E shows longitudinal bridge bonds. The iso-surfaces were plotted at levels of positive $\Delta\rho$ ($\Delta\rho > 0$ implies bonding and $\Delta\rho < 0$ indicates anti-bonding), shown by the magnitude scale at the bottom, that accentuate the dominant bonding modes suggested by each study.

All previous experimental measurements of bonding in aluminium involved X-ray diffraction. Conventional interpretations of the diffracted intensities assume that the X-rays scatter kinematically (once) from the crystal, but the reality is that there is always some degree of multiple (dynamic) scattering. Kinematic scattering theory provides a very simple relationship between X-ray diffraction intensities and the electron density in the crystal. In some crystals, including metals and highly perfect ceramic crystals, the kinematic approximation breaks down due to strong multiple scattering. To try to

"This work opens up the exciting possibility that bonding information might be gained directly from mechanical anisotropy rather than complex diffraction experiments."

be able to probe precipitates in general (not just T_1) in this manner and determine their structures with confidence, a very accurate knowledge of how electrons are scattered from aluminium is mandatory. To understand this, one needs accurate knowledge of how aluminium atoms are bonded together.

Atoms bond to one another by the very subtle re-distribution of their outer electrons. In other words, these outer *electrons act as an electronic glue that binds the atoms together*. The question being asked here is *where is the electronic glue in pure aluminium, or, what is the bonding electron density distribution between the atoms?* We must answer this question in pure aluminium to be able to begin considering the structure, growth and stability of precipitates in alloys.

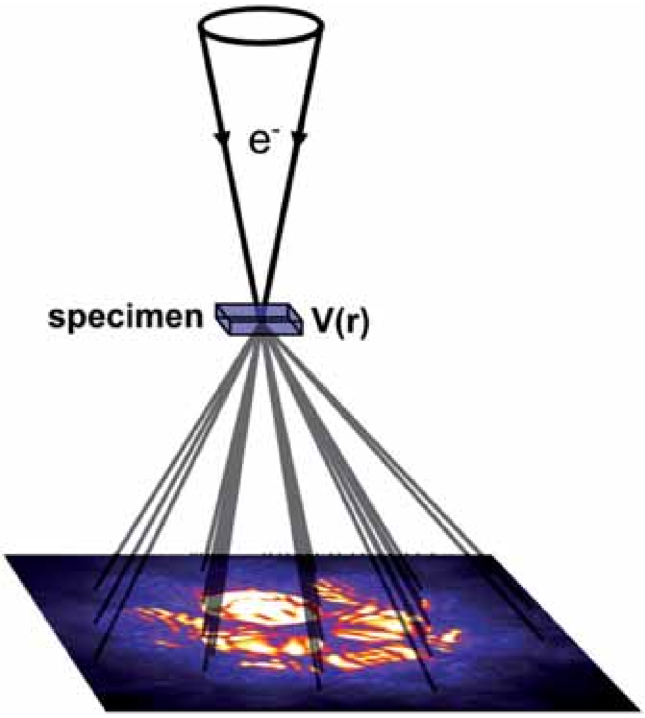


Fig. 3. A CBED pattern is formed when a conical beam of electrons is focussed onto a crystalline specimen. The electrons are scattered by the crystal potential *V(r)*. Different families of crystal planes that are close to or at the Bragg condition diffract the incident cone and the diffracted cones result in discs where the intensities oscillate as a function of angle, crystal thickness and crystal potential.

accommodate this, X-ray diffractionists introduce a correction term into their analysis called an extinction factor. This is used in attempts to 'correct' X-ray intensity data sets for the effects of multiple scattering.

The other problem in X-ray diffraction is the lack of an absolute scale. Scale and extinction are correlated in such a way that they can limit X-ray diffraction measurements of the total electron density ρ to uncertainties of order 10%, eliminating the bonding information which is a small perturbation Δρ, where Δρ is of order 5% or less.

In aluminium, the uncertainties due to extinction and scale errors in conventional X-ray diffraction measurements have prohibited accurate bonding measurements because aluminium is one of the best-known approximations to a free electron gas. This means that the localisation of electrons in bonds is such a weak perturbation to the total electron density ρ that the bonding electron density Δρ is obscured by the errors in the measurements. What is required is a technique that is not affected by extinction and scale issues and can measure ρ with uncertainties below 1%. Quantitative convergent beam electron diffraction (QCBED) is the answer.

QCBED

A CBED pattern is formed by focussing a conical beam of electrons onto a specimen in a transmission electron microscope (see Figs 1 and 3). Due to the very strong interaction of electrons with the crystal potential *V(**r**)* and the ability of even standard electron optics to focus electron beams into nanometre-sized probes, CBED patterns contain enormous amounts of information in their intensity distributions as a function of angle due to highly dynamic electron scattering from volumes of crystal ~9 orders of magnitude smaller than in X-ray diffraction. This means QCBED can be performed selectively from regions of perfect crystal in a specimen, in contrast to X-ray diffraction where one cannot be so selective. The intensity oscillations in a CBED pattern are a function of specimen thickness, angle of incidence, electron energy and crystal potential *V(r)*. QCBED involves fitting a calculated CBED pattern to an experimental one by varying these parameters until the best match is produced. The calculation is based on a full dynamic (multiple) scattering treatment of elastic electron diffraction, making extinction and scale irrelevant. Fitting such a pattern typically involves the matching of 10^4 data points with only 15 to 20 variable parameters. This ensures unique and highly constrained solutions and contributes to the accuracy and precision of the measurements. QCBED measures the crystal potential *V(**r**)*, which is directly related to and thus easily converted to electron density ρ*(**r**)* via Poisson's equation and the Mott formula [3].

QCBED was first demonstrated by MacGillavry [4] in 1940 and the first high-precision QCBED measurements were made by Goodman and Lehmpfuhl [5] in 1967 in MgO. The technique floundered due to the effort required to manually remove the diffuse inelastic electron scattering background from CBED patterns prior to matching with elastic scattering theory. The field was revived in the early 1990s with the advent of electron energy filters and CCDs, which allowed energy-filtered CBED patterns spanning a large linear dynamic range to be recorded. The last two decades have seen a rapid expansion of QCBED research, regularly achieving measurement uncertainties below 1% with the aid of electron energy filters [6].

Whilst capable of removing most of the inelastic signal in CBED patterns, even the latest energy filters are incapable of removing the significant diffuse background contributed by thermal diffuse scattering (TDS), arising from phonons. This is because energy losses from phonons

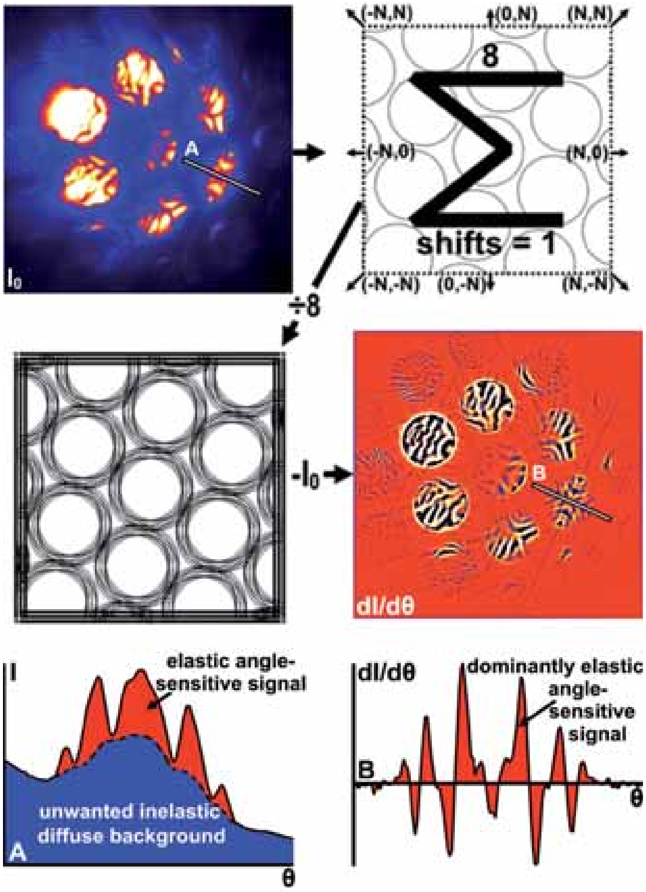


Fig. 4. The angular-difference technique generates the difference pattern by shifting the as-captured CBED pattern I_0 by a distance of N pixels in the eight principal directions shown, where N corresponds to the level of binning applied to the data before pattern matching. The shifts are averaged and the unshifted pattern subtracted from the average, producing the difference pattern dI/dθ. The large diffuse background caused by inelastic scattering has been almost completely eliminated (compare profiles along loci A and B).

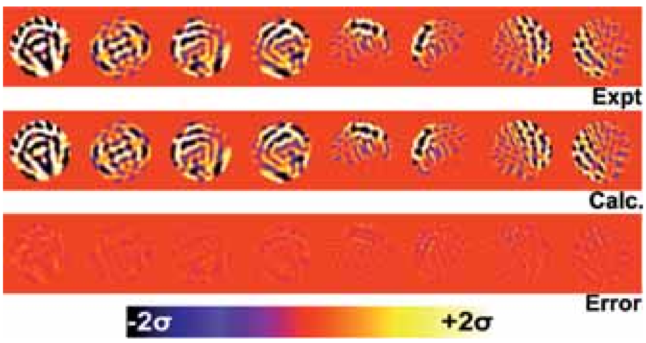


Fig. 5. The top row shows an experimental angular-difference CBED pattern. The middle row is the refined theoretically calculated pattern after allowing the sensitive parameters to adjust to their output values. The bottom row gives the difference between the experimental and calculated patterns in terms of the uncertainty associated with each pixel in the experimental pattern (error scale at bottom).

are of the order of 0.001 to 0.1 eV, whereas energy filtering is limited to an energy resolution of about 1 eV. The restriction of practical QCBED to microscopes with energy filtering optics has limited access to this field of research. Prompted by both these issues, a new area of QCBED has been developed, namely 'differential QCBED'. In the present study of aluminium, the angular-difference QCBED technique was applied, described as follows.

Angular-difference QCBED [7]: The oscillations in a CBED pattern that contain the elastic scattering signal are extremely sensitive to scattering angle, whilst the diffuse background originating from inelastic scattering is not (see profile A in Fig. 4). The angular-difference QCBED technique involves differentiating a CBED pattern radially with respect to scattering angle, as shown in Fig. 4. The resulting difference pattern contains almost no inelastic intensity information, as can be seen from comparison of the profile along locus B in the difference pattern with the profile along locus A at the same position in the as-captured CBED pattern.

Fig. 5 gives an example of angular-difference QCBED pattern-matching input, output and mismatch. Although some structure remains in the error map, the difference between theory and experiment is very small, resulting in low levels of uncertainty in the measured electron density parameters. The as-captured CBED patterns that were used in producing Figs 4 and 5 involved no electron optical energy filtering.

The development of differential QCBED has not only enhanced the precision and accuracy of interatomic bonding measurements by QCBED, but it has opened accurate electronic structure measurement by QCBED to any transmission electron microscope, regardless of whether it is fitted with expensive and sophisticated energy filtering electron optics or not.

Differential QCBED applied to aluminium

The details of the present electron density measurements in pure aluminium are given in [2]. In summary, electron transparent foils were electro-polished from a sheet of 99.9999+% pure aluminium and CBED patterns collected under a variety of experimental conditions resulting in:

- 140 CBED patterns at ambient temperatures
- 16 CBED patterns from a liquid-helium cooled specimen
- ~10^6 data points for the measurement of 14 electron density variables

- seven different zone axes from which CBED patterns were collected for several scattering geometries near each zone
- 156 different specimen thicknesses
- four different electron energies used (50, 120, 200 and 300 keV) for pattern collection.

The use of ~10^6 CBED data points for the measurement of only 14 independent electron density parameters under so many different experimental conditions not only ensured a unique and unequivocal determination of the bonding electron density in aluminium, but also revealed up to 20-fold improvements in the precision of QCBED over all previous X-ray diffraction measurements.

Bonding and material properties

Fig. 6 presents the Δρ plot obtained from the present QCBED measurements and a density functional theory (DFT) calculation of Δρ performed by Dr Andrew Smith, a co-author of [2], using the Wien2K package [8] (FPLAPW/GGA +lo +ls formalism). These plots stand in contrast to those in Figs 2B–2E by showing that the bonding electron density is concentrated entirely in the tetrahedral holes in aluminium. The corresponding points on the graph of Fig. 2A show that the present benchmark QCBED measurements are in closest agreement with the present DFT calculation.

Mechanical anisotropy

A relationship between the bonding electron density Δρ, the bonding potential ΔV, and Young's modulus E in any crystallographic direction was derived in [2] using simple Coulombic arguments. It states that the distance of an atom from the $\Delta V = 0$ iso-surface should be proportional to $1/\sqrt{E}$ in any direction, and the magnitude of the bonding electron density intersected by the $\Delta V = 0$ iso-surface should be proportional to E. Fig. 6 presents plots of the $\Delta V = 0$ iso-surface with the magnitude of Δρ intersected by this surface mapped in colour, for both the present QCBED and DFT determinations. These surfaces are compared with the plot of the $1/\sqrt{E}$ surface where the magnitude of E is coloured onto it. The QCBED-derived surface bears a striking resemblance in terms of shape and colouration to the surface derived entirely from elastic constants [9]. The resemblance is slightly diminished for the DFT-generated surface, however, there is still good qualitative agreement. This work opens up the exciting possibility that bonding information might be gained directly from mechanical anisotropy rather than complex diffraction experiments.

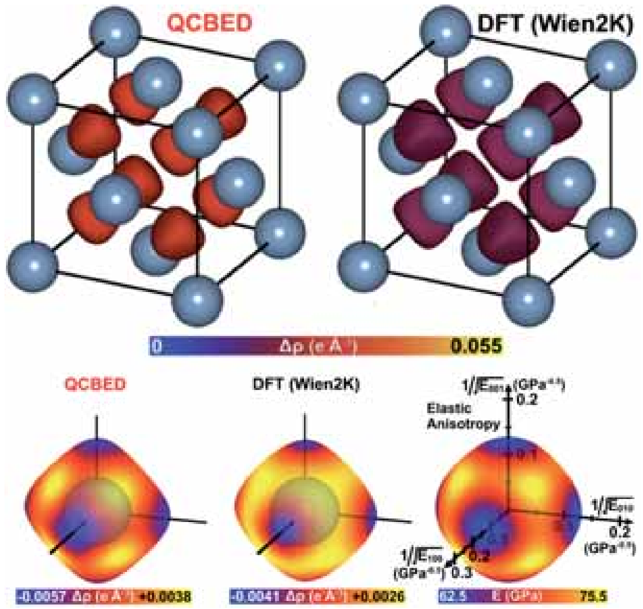


Fig. 6. The bonding electron density Δρ determined by the present angular-difference QCBED measurements (top left) and the DFT calculation (FPLAPW/GGA +lo +ls) by Smith of [2] (top right). The iso-surfaces are drawn at 50% of the maximum positive value attained by Δρ in each determination. The magnitude of Δρ is indicated by the colour scale. In the lower half of the figure, plots of the $\Delta V = 0$ iso-surface for the QCBED and DFT determined bonding electrostatic potential are given with the magnitude of Δρ that this surface intersects coloured onto each surface (see colour scale below each plot). The surface labelled elastic anisotropy is the $1/\sqrt{E}$ surface (where E is Young's modulus in any direction) with the magnitude of E mapped onto it. The two surfaces at left and centre are thus entirely derived from bonding information, whilst the surface at right is entirely derived from published elastic constants [9].

"A new approach to QCBED has allowed the metallic bond in aluminium to be characterised unequivocally for the first time in over 80 years of experimental and theoretical investigation."

Evolution of alloys along commercial processing routes

A strong correlation between the form of the bonding electron density in the matrix metal (aluminium) and the shapes of strengthening precipitates in a large range of aluminium alloy systems is becoming evident. This provides the exciting prospect of considering (aluminium) alloy evolution, ie. nucleation and growth of secondary precipitate phases, from the point of view of changing electronic environments within an alloy as it is aged. It is suspected that purely atomic models will not be sufficient to unravel the fundamental mysteries of alloy evolution, and that the electronic structure (bonding electron density distributions) within evolving alloys is the key to understanding and fundamentally optimising commercial alloy production processes.

Understanding how strengthening precipitates function

The original motivation for the present study was the determination of atomic structure in strengthening precipitates like T_1, which requires accurate knowledge of how aluminium atoms bond to one another. One might, however, be able to go further and determine the nature of bonding within the precipitate, as well as across the matrix/precipitate boundary. It is suspected that for a secondary phase to be able to have a strengthening effect in an alloy, the bonding within the precipitate as well as the bonding across the matrix/precipitate boundary must be stronger than the bonding within the matrix itself. Only detailed and highly localised electron density measurements can prove whether this is in fact the case. Angular-difference QCBED may be the only technique that can make these highly localised measurements [10].

Summary

A new approach to QCBED has allowed the metallic bond in aluminium to be characterised unequivocally for the first time in over 80 years of experimental and theoretical investigation. This knowledge is essential to understanding the role of interatomic bonding in stabilising atomic scale strengthening precipitates in alloys. This information will not only aid structure determination of strengthening precipitates in commercial aluminium alloys, but will also contribute to a deeper understanding of the evolution of commercial alloys as they are processed.

Angular-difference QCBED has measured the electron density in aluminium with up to a ~20-fold improvement in uncertainties over all previous X-ray diffraction measurements. This high precision was crucial in establishing that the bonding electrons are located exclusively in the tetrahedral interstices of the fcc structure. These measurements were also of sufficient precision and accuracy to allow the anisotropic mechanical properties of aluminium to be equated accurately to bonding potential and electron density. These measurements have also allowed a first-principles solid-state DFT to be benchmarked and identified as predicting the correct electronic structure for aluminium.

Electron density is the fundamental basis for first principles solid-state theory and armed with an experimentally verified theory, one can predict the behaviour of more complex aluminium-based systems (alloys) with new levels of confidence.

Acknowledgements

I thank my co-authors in [2], the subject of this article: Dr Andrew Smith, Prof. Joanne Etheridge and Emeritus Prof. Barry Muddle. I also thank my many colleagues in the Monash Centre for Electron Microscopy, the ARC Centre of Excellence for Design in Light Metals and the Department of Materials Engineering at Monash University. Finally, I thank the National Measurement Institute not only for the award of the Barry Inglis Medal in 2011, but also for the promotion of measurement research in Australia through the World Metrology Day awards and celebrations. [A news report on the award of the Barry Inglis Medal to the author appeared in *AP* **48**(6), 170 (2011) – Ed.]

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Bill Ellis (1921 – 2011)

Marc Duldig
University of Tasmania

Graeme Reade Anthony (Bill) Ellis was born in Launceston on 20 December 1921. Bill was educated at the University of Tasmania completing a BSc (Hons), PhD and DSc. He served with the RAAF and was a navigator with the RAF between 1942 and 1945. In 1950 he became a scientific officer with the Ionospheric Prediction Service (IPS) where he published work showing that radio waves of frequency as low as 1 MHz could penetrate the ionosphere in certain circumstances. Tasmania was one location where this was possible. It was as a result of correspondence on this subject between Bill and pioneer radio astronomer Grote Reber, that Reber decided to move from the US to Tasmania to continue low frequency observations.

In 1957 Bill spent a year at the University of Queensland as a senior lecturer. From 1958 to 1960 he was a principal research officer at CSIRO's Upper Atmosphere Section. Here he worked on very low frequency radio waves, predicting the existence of a new type of very low frequency emission, the 'nose whistler'. In 1960 he was appointed professor of physics at the University of Tasmania. His appointment was very timely, injecting new vitality both in teaching, where he was very popular, and in establishing new research directions. He remained in this position until his retirement in 1982 when he received the title of emeritus professor.

His 30 year study of radio emissions from Jupiter resulted in the development of a very advanced technique to determine the dynamic spectra of bursts of these emissions. Bill was a foundation member of the Australian Research Grants Committee which led to national funding for research in universities and eventually evolved into the Australian Research Council. In 1963 he was awarded the Australian Academy of Science Lyle Medal, and in 1965 he was elected to Fellowship of the Academy. In 1984 he was made an Officer of the Order of Australia.

Bill had an excellent sense of humour and a redoubtable ability to solve technical problems quickly and with a minimum of fuss. During Bill's time in the Physics Department, morning and afternoon tea were an institution attended by everyone. Sometimes there were up to 50 people in the tea room. On one occasion in the late

[Courtesy: Susan Blackburn]

1970s there was a public holiday and the secretarial staff were away. The small cupboard that held all the tea and biscuits was locked and only the secretary had a key! Bill marched in to find most of his academic and technical staff standing around in a state of bemusement. Without hesitation Bill called over the workshop manager and said, "Well, drill out the top rivets we don't have all day!" After morning tea Bill told everyone that the top of the cabinet would be put back in place and the 'all powerful' secretary need be none the wiser. At Bill's retirement the technical staff presented him with a beautiful wood panel covered in knobs, switches and dials for him to use as the inveterate tweaker.

At Bill's funeral Bob Delbourgo, who succeeded Bill as department head, recounted: "The mid 1970s were the heyday of Physics at the University of Tasmania with 22 staff members and over 200 first-year students. Things have changed but the research work in radio physics has gone from strength to strength. Bill left an indelible mark on physics development in the university through his research work and his students, principally Pip Hamilton and Peter McCulloch. The thriving radio-astronomy research today is largely because of Bill's foundations and this is surely how he will be remembered."

Bill died in Hobart on 4 February 2011. His wife Helen predeceased him and he is survived by his children Elizabeth, Susan and David, and his grandchildren Chris, Anna and Hannah.

I thank Martin George, Peter McCulloch, Bob Delbourgo and the Ellis family for additional material.

OBITUARY

Phillip Law (1912 – 2010)

Craig Robertson

One can hardly avoid the notion of 'Renaissance man' in looking at Phillip Law's life: scientist, explorer, teacher, sportsman, musician, writer, patron of the arts, and perhaps above all, a prince of administration. There were significant achievements in every calling.

He was born in Tallangatta, Victoria, in 1912 and spent much of his childhood following his father's teaching appointments in country towns, where he developed his love and skills for outdoor life. He was a keen sportsman throughout his life, winning the Australian Universities Lightweight Boxing Championship in 1936.

Law's career began at Melbourne Teachers College in 1932, studying science and mathematics. After teaching in a country school for two years, he resumed second and third year physics at the University of Melbourne, while teaching full-time, and took out his BSc with first-class honours in physics in 1938. A year later he began a Masters degree and was appointed a demonstrator and lecturer in Melbourne's School of Natural Philosophy. In 1941 Law married artist Nel Allan. She was the first Australian woman to go to Antarctica, where she painted landscapes.

With the outbreak of World War II, Law decided to join the RAAF but was persuaded to continue working with the Optical Munitions Panel which was responsible for improving optical equipment ranging from binoculars to artillery sighting. At the Melbourne campus, he led a vigorous support of the war support that gave him a taste for public speaking. In 1944 the Australian Army sent him on a scientific mission to visit the battlefronts in New Guinea.

After the war, Australia's interest in Antarctica grew significantly. By then Law had gained extensive experience in skiing and hiking in the Australian Alps. He joined the fledgling Australian National Antarctic Research Expeditions (ANARE) and, in January 1949, he was made its leader and the first Director of the newly created Antarctic Division of the Department of External Affairs. Getting a foothold on the Antarctic mainland became a personal obsession.

Exploration began in earnest in 1954 with the first voyage of the *Kista Dan*, which led to the founding of Mawson Station. In the following years Davis (1957) and Casey (1959) stations were founded, and 4800 kilometres of unknown coastline explored. He took the first recorded scuba dive in Antarctica's icy waters. Law made 28 expeditions to Antarctica over the period 1947–66, during which he built the administration of the Antarctic Division and led ANARE and its scientific programs.

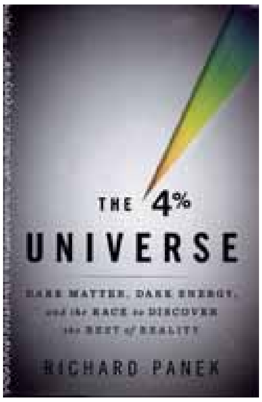
The International Geophysical Year in 1957–58 resulted in many achievements in upper atmosphere and space physics, biology and geology. Law built on these achievements and contributed to the creation of the Antarctic Treaty. In 1960 he received the Founder's Gold Medal from the Royal Geographical Society of London.

In 1966 Law made the transition from explorer to educationist. The Victorian Institute of Colleges was to become his greatest achievement as an administrator. Under Law's directorship the Victorian tertiary college sector expanded to 16 colleges by the time of his retirement in 1977. The finest example of his innovation was the Victorian College of the Arts – his proudest achievement because it was his own idea.

A skilled and highly popular public lecturer, Law gave hundreds of lectures to large attendances, especially on Antarctica during his explorer days. While President of the Royal Society of Victoria, he helped shape its annual lecture series. Among many other activities he served as President of the Melbourne Film Festival and of the Melbourne Film Society.

His wife Nel died in 1990. There were no children from their marriage. Phillip Law's extraordinarily productive life ended at the age of 97 on 28 February 2010.

[This obituary is based on an interview conducted by Craig Robertson in January 2006, as part of a project for the Royal Society of Victoria. Photo credit: Ian Toohill]



The 4% Universe – Dark Matter, Dark Energy and the Race to Discover the Rest of Reality

By Richard Panek
Houghton Mifflin Harcourt, New York, 2011, 297 pp.
ISBN 987-0-618-98244-8
Reviewed by Jason Dicker, Launceston College

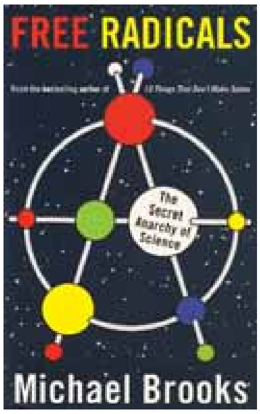
This is a highly topical, well written account of the discovery of the acceleration of the Universe for which the leading proponents have just received the Nobel Prize for Physics. The book is an easily readable, fast paced account of the merging of cosmology into full mainstream physics as newer instrumentation has allowed the previously speculative models of the Universe to be quantified and values given to Lambda and Omega. It is obviously an American book written largely for the US market with the odd amusing reference that will stop some Australian younger readers. It is very difficult to tell if other international groups were involved in the story, although proper mention is made of international telescopes and workers.

Panek has obviously had excellent sources for his research prior to writing this book. He has looked into the historical backgrounds of both the problems associated with cosmology and the people and traces the key issues of expansion and shape from Einstein through to Sandage, Hoyle, Zwicky and others.

The main theme is the competition between the two groups who both arrive at the same conclusions at nearly the same time through different mechanisms, the 'particle physics group', the Supernova Cosmology Project team under Saul Perlmutter, and the 'astronomy team', High-*Z* with Brian Schmidt and Adam Riess. Panek describes the background of the key members of each team, and how they develop their approaches in order to come to their results.

Panek completes the book by describing the continued confirmation of the results by other researchers and how supernovae identification is now fully automated and routine. He goes on to describe the problem that Dark Energy has had on all physics and the searches for possible candidates, the neutralino, the axion and so on, but leaves the issue open as indeed it is.

It is a book for the general public but really the reader should have at least a general knowledge of cosmology. I have thoroughly enjoyed the book as a person with Physics and Astronomy training but many years away from the frontline if ever I was. As a teacher, I have students who want to know some of what is contemporary knowledge and research. This book emphasises the need for data, the competition and the sheer effort needed to operate in modern research, but also the joys of making absolutely fundamental discoveries that can change human perspectives.



Free Radicals – The Secret Anarchy of Science

By Michael Brooks
Profile Books, London, 2011, 312 pp.
ISBN 978-1-84-668405-0
Reviewed by John Daicopoulos, James Cook University

Michael Brooks's latest book 'Free Radicals' was written for people like me, albeit about 25 years too late. When I arrived at university for undergraduate physics, my impression was that the department would be a beacon of discourse, rational argument, and collegiality. Oh the horror of it all.

Bickering, infighting, the sabotaging of equipment, interrupting visiting lecturers during their talks, the third floor staff would not talk with the fourth floor, the experimentalists would not talk with the theoretical staff, and few bothered to communicate with the undergraduate staff. Everyone concerned called this state of affairs a pathological, but normal, situation. Personalities reigned supreme and egos were in charge. I was more than a little naive, and definitely stunned.

Brooks chronicles several infamous incidences of how the strong will of scientists was a crucial catalyst leading to both academic and social indiscretions. Not that all of these dalliances were negative, many were at the root of great discoveries while other, drug fuelled sessions, relaxed the creative minds of leading academics.

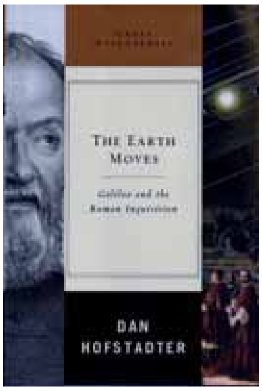
Brooks has done his research well covering episodes from all of the major sciences. For physicists, his exposé of the Eddington–Chandrasekhar affair is an enlightening illustration of just how powerful, and academically discriminatory, someone can be. Fortunately, the likes of Chandrasekhar managed to rise above the fray, the effects on others remain untold. The Eddington–Chandrasekhar

affair highlights just how personality driven these escapades really are.

As the subtitle of the book suggest, the underlying theme focuses on the requisite role anarchy plays in the scientific endeavour; Brooks uses the word *anarchy* often describing how individuals took it upon themselves to swim against the tide of ethics committees, colleagues or even conventional wisdom.

Many readers will disagree with Brooks's take on the episodes he has chosen to illustrate his argument, and some will be miffed that he has dared to open the door on our indiscretions. I for one am glad he has, and done it with style to boot.

The overall sense of 'Free Radicals' is positive, and rightfully so. Brooks makes his point that anarchy is a necessary characteristic for a successful scientific career – it is an important skill to learn, with the hope that the pathological nature in some of us could be set aside, but I've been fooled once before.



The Earth Moves – Galileo and the Roman Inquisition

By Dan Hofstadter
W. W. Norton, New York, 2010, 240 pp.
ISBN 987-0-393-06650-0
Reviewed by Jason Dicker, Launceston College

My first reaction was, 'not another Galileo book', but on reading this I was highly impressed by the research done by the author into the basic topic, the infamous Inquisition, and gained a much greater insight into not just the politics of the day but the culture of the Baroque Roman church as it wrestled with enormous changes taking place.

Galileo was in many ways the ultimate consequence of the Renaissance era of poetry, knowledge and liberal development. He was not just a mathematician, but a poet, musician, lover of architecture, and a close friend of artists and writers. However, the Church of Rome was still dominated by mediaeval era dogmas and beliefs. Aristotle was entrenched through Thomas Aquinas in Church thinking to the point where disputing Aristotelian ideas were to bring you under suspicion. Such works as Dante's 'Inferno' that were geocentrically based with their crystalline spheres around the Earth heavily biased people's ideas of the Universe. Thinking in a heliocentric manner as espoused by Copernicus and Galileo was simply 'wrong'.

Hofstadter analyses Galileo's telescope development and carefully works through why Galileo was converted to the Copernican point of view and how he could not see why everyone else should not also accept his word or view for themselves. He does this sensitively, carefully looking at the various groups within the Church and their reactions, including those academics who, regardless, were going to support Aristotle because that is what they knew and were not open to change. Above all he looks at Maffeo Barberini Urban VIII and the positions in which that person found himself. This is well done, as Hofstadter carefully places Urban in the context of Italy in the early 17th Century, as one who will 'lose face' if either he supports Galileo against earlier Church pronouncements or have Galileo brought to trial as, by this time, Galileo's fame was enormous.

I was very interested in the purpose of an Inquisition into a person's beliefs and Hofstadter has obviously deeply studied these operations. That it was clearly a process of control by the Church of the total congregation is made quite clear. That thinking was more broadly accepting of alien concepts in the Church before the Roman Inquisition process began in 1542 is made clear. It places the whole Galileo affair in, for me, a much clearer light. This was not a 'simple' modern world with modern justice systems, this was an arcane world where nascent science butted into beliefs thousands of years old and deeply entrenched in society. To say that the Church was 'wrong' in taking Galileo to task is to ignore the realities of Italy as a highly sophisticated society that lacked science as a process until this time. No wonder Galileo ran into trouble, but he still retained his fame at the end of it and Urban, who possibly regretted the whole affair, certainly came off worse.

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Sinteron 2010 is welcome news for those involved in photonic sintering of conductive inks for printed electronics in areas such as displays, smart cards, RFID and solar applications. The non-contact, low thermal characteristics for this process make it suitable for web-based printing techniques such as inkjet, flexography, gravure, and screen print.

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Fast Piezo Focusing Systems for Microscopy

Warsash Scientific offers a more affordable series of fast piezo focusing devices with the new PIFOC system packages from PI. These packages are designed to improve results in fast focussing and lens positioning, as well as in deconvolution/3D imaging, and reduce costs at the same time.

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- AR coatings from Acton Optics

In creating the new PyLoN platform, Princeton redesigned its industry-leading Spec-10 family of cameras to remove the external controller, increasing experimental flexibility while further improving the ultra-low-noise electronics. Liquid nitrogen cooling virtually eliminates dark current, and readout noise has been further reduced from the already low levels in the Spec-10 platform.

PyLoN is available with Princeton's unique eXcelon technology which delivers the highest sensitivity in the UV and NIR while suppressing etaloning that occurs in standard back-illuminated deep depletion or back-illuminated CCDs.

The camera includes a GigE interface allowing operation at four times higher speed that its predecessors, and is supported by Princeton's 64-bit LightField software with Intellical wavelength and intensity calibration option. No other spectroscopy CCD is this cool, this quiet and this fast!

Vitara Ultrafast Laser

Coherent's new Vitara is the first widely tunable, ultrafast laser to deliver pulsewidths shorter than 12 fs, while also offering true hands-free and fully automated operation. This includes automated wavelength tuning from 755 to 860 nm and push-button bandwidth adjustment from 30 to 125 nm.

Features:

- Fully automated for hands-free, reliable operation
- Computer controlled bandwidth (<30 to >125 nm)
- Computer tunable centre wavelength
- PowerTrack active optimisation
- <12 fs pulsewidth capability
- Low noise (<0.05% rms)
- Integrated Verdi-G pump laser
- Compact footprint

Vitara's 125 nm maximum bandwidth delivers a specified pulsewidth of <20 fs directly from the laser output. In addition, the optional compact compressor enables the Vitara pulsewdith to be further compressed to 12 fs or less. Other options for Vitara include a new generation CEP stabilisation module that delivers the industry's highest phase stabilisation specification, and a Synchrolock module for external pulse timing stabilisation.

Applications for Vitara include seeding short-pulse amplifiers and CEP-stabilised amplifiers, which benefit from Vitara's stability and bandwidth, as well as pump probe spectroscopy where the short pulsewidth is an important advantage.

Engineered to meet the ultimate stability requirements of CEP stabilisation, Vitara demonstrates unprecedented levels of stability in the most challenging environmental conditions and most demanding applications. No other laser offers this combination of exceptional performance, flexibility and power in a solid, hands-free package.

For further information please contact Paul Wardill or Dale Otten on sales@coherent.com.au
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116 Sir Donald Bradman Drive, Hilton, SA 5033
Tel: +61 8 8150 5200; Fax: +61 8 8352 2020;
Web: www.coherent.com.au

AGILENT TECHNOLOGIES

High Resolution Wide Bandwidth Arbitrary Waveform Generator

Agilent Technologies has added a high-resolution, wide-bandwidth, 8- or 12-GSa/s modular instrument to its portfolio of arbitrary waveform generators. The new M8190A arbitrary waveform generator is able to deliver simultaneous high resolution and wide bandwidth along with spurious-free dynamic range and very low harmonic distortion.

This functionality allows radar, satellite and electronic warfare device designers to make reliable, repeatable measurements and create highly realistic signal scenarios to test their products.

The M8190A helps engineers:

- build a strong foundation for highly reliable satellite communications
- generate multilevel signals with programmable ISI and jitter up to 3 Gb/s.

The M8190A offers:

- 14 bits of resolution and up to 5 GHz of analog bandwidth per channel simultaneously
- the ability to build realistic scenarios with 2 GSa of waveform memory
- reduced system size, weight and footprint with compact modular AXIe AWG capability.

The high performance of the M8190A arbitrary waveform generator is made possible by a proprietary digital-to-analog converter (DAC) designed by the Agilent Measurement Research Lab. Fabricated with an advanced silicon–germanium BiCMOS process, the DAC operates at 8 GSa/s with 14-bit resolution and at 12 GSa/s with 12-bit resolution. At 8 GSa/s, the Agilent DAC delivers up to 80c-dB SFDR.

More information is available at www.agilent.com.au/find/M8190.

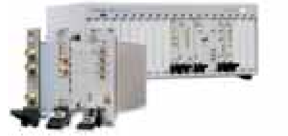
Agilent PCIe High-Speed Digitiser

Agilent U1084A is a dual-channel, 8-bit PCIe digitiser with up to 4 GS/s sampling rates, 1.5 GHz bandwidth and incorporates a 15 ps trigger time interpolator for accurate timing measurement.

The U1084A's digitiser technology combines fast analog-to-digital converters with on-board field programmable gate array technology allowing original equipment manufacturers to easily design-in high-speed signal acquisition and analysis.

More information is available at www.agilent.com.au/find/u1084a.

One Box EMI Receiver that Enhances Compliance Testing



Agilent Technologies has announced the introduction of the N9038A MXE EMI receiver, which is designed for laboratories that perform compliance testing of electrical and electronic products. The MXE enhances electromagnetic interference (EMI) measurement accuracy and repeatability with a displayed average noise level of -163 dBm at 1 GHz. This represents excellent input sensitivity, an essential receiver attribute that reduces the effects of electrical noise.

The MXE is fully compliant with CISPR 16-1-1 2010, the International Electrotechnical Commission recommendation that covers measurement receivers used to test conducted and radiated electromagnetic compatibility of electrical and electronic devices. With outstanding measurement accuracy of ±0.78 dB, the MXE exceeds CISPR 16-*1*-1 2010 requirements.

The built-in suite of diagnostic tools, including meters, signal and measurement lists, markers, span zoom, zone span and spectrogram displays, makes it easy to monitor and investigate problem signals. The MXE is also an X-Series signal analyser capable of running a variety of measurement applications such as phase noise. By enhancing the analysis of noncompliant emissions, these capabilities enable EMI test engineers and consultants to evaluate signal details and deliver new insights about the products they test.

More information is available at www.agilent.com.au/find/MXE.
For further details, contact tm_ap@agilent.com.
Agilent Technologies Australia Pty Ltd
Tel: 1800 629 485
Web: www.agilent.com.au/find/promotion

CONFERENCES IN AUSTRALIA 2012

17 – 18 February 2012
Physics Teachers Conference
Monash University, Melbourne, VIC

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

30 July – 3 August 2012
ANU Nuclei in the Cosmos Winter School
ANU, Canberra, ACT

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

12 – 17 August 2012
Seventy-fifth Annual Meeting of the Meteoritical Society
Cairns Convention Centre, QLD

23 – 28 September 2012
Thirty-seventh International Conference on Infrared, Millimetre and Terahertz Waves
Wollongong, NSW

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

A Leading Manufacturer in Pulse Generator and Custom Laser Technology

Pulse Generator Technology from Quantum Composers

Quantum Composers provides innovation and value to our customers with our diverse family of Precision Pulse Generators. Our wide range of pulse generator technology has been created to fit the needs of any budget and application. Our pulse generators provide a cost-effective method to create and synchronize multiple sequences, delayed triggering, or any precisely timed series of events.

9500+ Digital Delay Pulse Generator

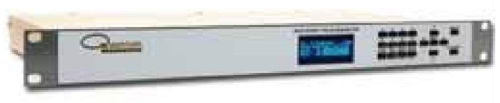
Our 9500+ series of pulse generators provides a cost-effective yet highly flexible and functional approach for your synchronization and timing needs.

9520 Digital Delay Pulse Generator

Our 9520 Series Pulse Generator provides the utmost flexibility and performance in a bench-top digital delay pulse generator.

9530 Digital Delay Pulse Generator

Our 9530 Pulse Generator provides the latest in laser timing and synchronization. Offering a unique 1U 19″ rackmount package with all rear panel connections, it is well suited for integration into your rack timing and control systems.



9600+ Digital Delay Pulse Generator

Our 9600+ Pulse Generator is the most affordable Digital Delay Pulse Generator in our family of products. Despite its low cost, this robust model offers a full range of features, making it ideally suited for the budget sensitive user.

Lastek Pty Ltd

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