Australian Physics

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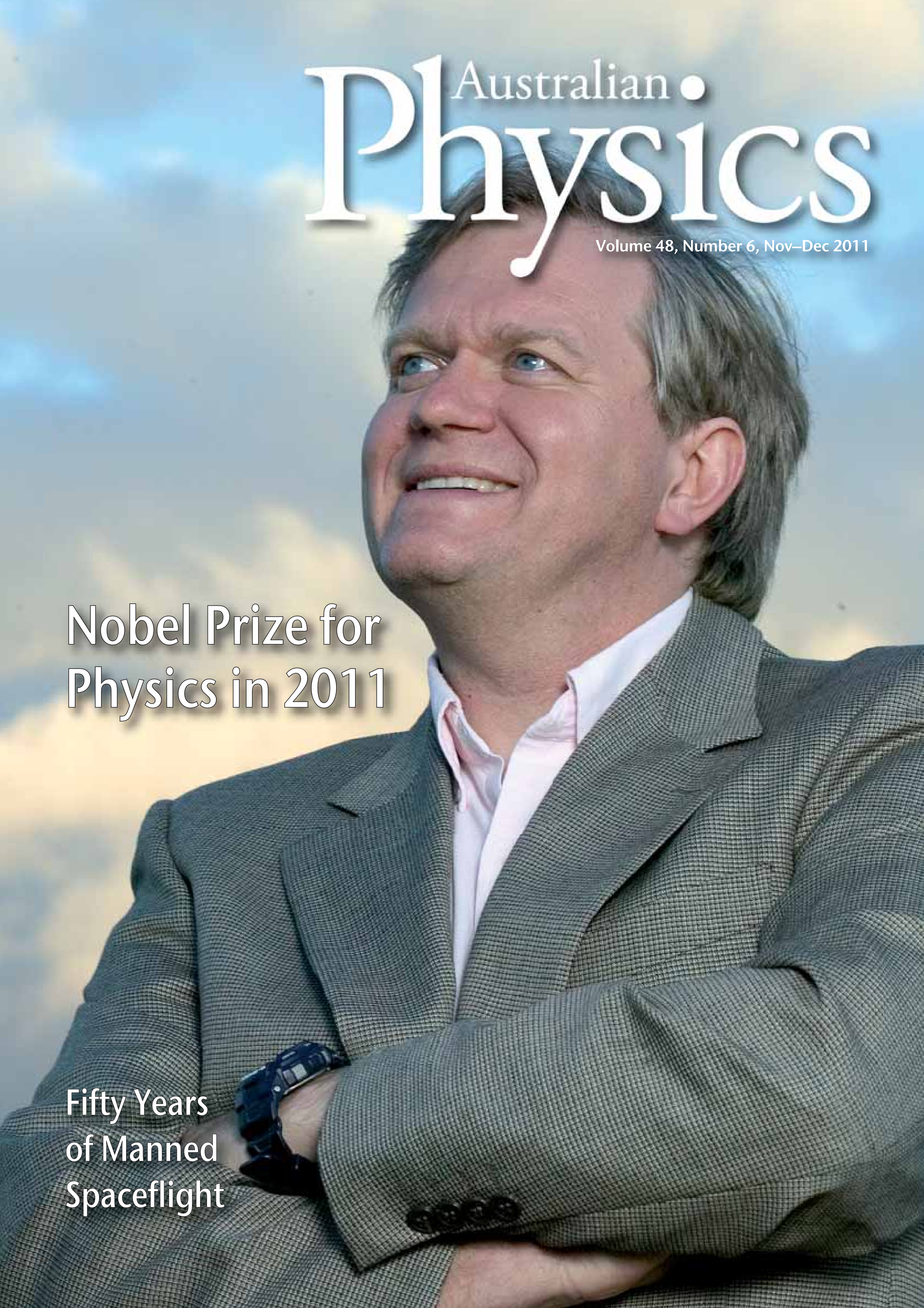

# Nobel Prize for Physics in 2011

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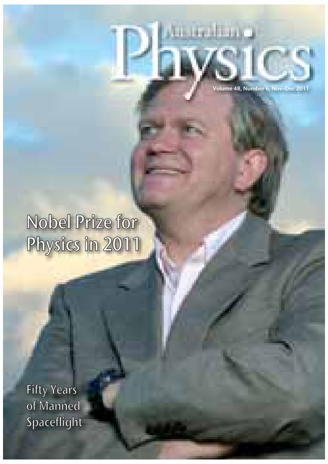


## Cover

Professor Brian Schmidt (Australian National University) has been awarded the Nobel Prize for Physics in 2011. He shares the prize with Professor Adam Riess (Johns Hopkins University) and Professor Saul Perlmutter (University of California, Berkeley) for their discovery that the Universe is expanding at an accelerating rate – see pages 169, 173 and 175. [credit: Belinda Pratten and the ANU]




# Australian Physics

**A Publication of the Australian Institute of Physics**

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




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

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# EDITORIAL

## Nobel Prize for Physics

In the 1990s two teams, one led by Brian Schmidt (ANU) and the other by Saul Perlmutter (U. California), raced each other to find evidence that the expansion of the Universe is slowing down because of the effects of gravity. To the astonishment of both teams, they found exactly the opposite – the expansion is accelerating, a profound discovery that has been rewarded with this year's Nobel Prize for Physics.

While Adam Riess (Johns Hopkins) was a member of the Schmidt group, it is well worth noting that two prominent members of the Perlmutter group were the Australian astronomers Brian Boyle (CSIRO) and Warwick Couch (Swinburne University of Technology), so Australia can rightly claim a significant share of the discovery.

Although Australia has won more than its fair share of Nobel Prizes in Medicine, it has been a long time between drinks for Physics. The only other occasion Australia can lay claim to the prize was the award in 1915 to father and son William and Lawrence Bragg for their development of X-ray crystallography.

There are some interesting parallels between the two prizes. William came from England to take up a chair at the University of Adelaide. He married, raised a family and eventually the family returned to England. William and Lawrence carried out the research that led to their Nobel Prize on English soil. In contrast, Brian Schmidt was born in the US and moved to the ANU in 1995. The research that led to his Nobel Prize was carried out on Australian soil.

Congratulations again to Brian!

Until the Nobel announcement our cover story was to have been the article on manned spaceflight by Jonathan Nally on page 181. If you are a regular listener to Robyn Williams' *Science Show*, you will be aware of the excellent segments that Jonathan presents on astronomy and space science. Jon said he does not mind in the least being 'bumped off' the front cover by such good news!

At the beginning of this year we set ourselves the goal of getting the magazine back on schedule by the end of the year. I'm pleased to note that we have achieved that goal, but only because of the hard work of our production team. I would like especially to thank our Assistant Editor Akin Budi, Guy Nolch at Control Publications, Rod Johnson and Ray Leung at Pinnacle Print Group, Che Giblin at MailPro, and Kim O'Dea at Waldron Smith Management.

On behalf of the production team, we wish you all the best for the coming Season and look forward to a successful 2012.

**Peter Robertson**

# National and international activities of the AIP

Instead of an opinion piece it is time to bring members up to date with some of the national and international activities that the Institute has been involved in. Before I do this I must congratulate Michelle Simmons on her award as the NSW Scientist of the Year.

The AIP is a founding member of the Association of Asia Pacific Physical Societies (AAPPS). AAPPS has not been a particularly high profile organisation but it is starting to flower and develop its potential. In the fastest growing region for science and with a huge population base AAPPS is in the right place to become a significant force in international physics. AAPPS has been actively pursuing increased linkage with Europe and there have been a couple of joint conferences aimed at enhancing collaborative scientific ventures. AAPPS has also decided that it needs an internal divisional structure. It will be forming discipline and non-discipline based divisions starting with areas that already have some level of integration across the region and where the existing bodies might serve as seeds for the new divisions. An example of a non-discipline division is Women in Physics, an area that needs strong support across much of the region and where some existing organisations can offer a great start. Some of you may already have heard about one or more of the divisions or even been invited to play a part. I encourage you to get involved. Planning is also underway for the Asia Pacific Physics Conference which will be held in Japan in 2012.

Another international activity was the International Union of Pure and Applied Physics (IUPAP) General Assembly. I attended with two other Australian voting delegates, the AIP Vice President Rob Robinson and another AIP member, Bruce McKellar. The most exciting aspect of the meeting was the nomination of Bruce as President Elect. Bruce was elected unopposed and will serve on the executive until he automatically takes up the Presidency at the next General Assembly in three years time. This is the first time a southern hemisphere member has been elected to the Presidency and our congratulations go to Bruce.

The IUPAP GA was hosted by the Institute of Physics (IOP), the organisation from which the AIP grew. I spent some time in discussions with the IOP looking at strengthening our bonds. Discussions with the Membership manager were most helpful as they quickly resolved an issue that had raised some tension among our own members. There is an option for AIP members to join the IOP at significantly reduced rates. Many members take up this option but were dismayed or even offended when their membership cards indicated they were Affiliate Members, a grade for people with no qualifications, but an interest in physics. This was a lack of communication between our organisations. The IOP constitution requires all members to go through a nomination and vetting process. Therefore AIP members requesting the discount simply have to complete the membership application form for their appropriate grade, include their CV etc., but note in the cover letter that they are an AIP Member or Fellow. This will expedite processing and on completion they will become Members or Fellows of the IOP and be able to use the MInstP or FInstP post nominal. More importantly, independent of their membership grade there is no more to pay and future year fees will continue to be discounted in the same way.

Finally, closer to home, FASTS has undergone a rebranding and is now trading as Science and Technology Australia. STA has been going through some challenging times with the government reducing the grants that helped it operate, but it has restructured its activities and should be able to continue to represent scientists to the politicians and bureaucrats. It has had a very effective year with greatly increased media presence, playing a significant part in the removal of the ERA journal rankings system, running the highly successful Science Meets Parliament and Science Meets Policymakers and will soon host Science Meets Superannuation to look at how the superannuation managers might invest a portion of their funds into science.

In closing I wish you all the best for the festive season. May your holidays be safe and refreshing and may 2012 be all you could wish for.

**Marc Duldig**

# LETTERS

Dear Editor,

I am grateful to Jeffrey Crosbie for his letter 'On absorbed, equivalent and effective radiation doses' in *Australian Physics* **48**(4), 102 (2011), in answer to my plea for information about the current units of nuclear radiation exposure.

I'm happy to confirm that the Gray and the Sievert are now as clear as the rad and the rem were to me when I was a junior Health Physicist back in 1959, at the then-new nuclear power station at Chapelcross in Scotland.

At that time, when four 150 MW reactors were operating at full power, gamma-ray intensities of about 0.6 μSv/hr (microSievert/hour) were measured at the gates to the Chapelcross site. This is some 1000 times less than the reported level of 0.6 mSv/hr (milliSievert/hr) at the gates of the (damaged) Fukushima reactors.

Sincerely,

Dr John C. Macfarlane
Launceston, TAS

---

Dear Editor,

I am writing in response to the article by Frank Larkins in the July–August issue of *Australian Physics* [**48**(4), 105–8 (2011)] on 'Excellence in Research: Measuring the Performance of Physics'.

The commentary relates to the statement:

'All the sub-disciplines were rated at or above world average (≥3) with the exception of AMNPPP (Atomic, Molecular, Nuclear, Particle and Plasma Physics – code 0202), a sub-discipline with a very broad classification category of different sub-fields with no insight being provided into the relative standings available.'

Perhaps the following observations provide some insight into this performance. The Australian Bureau of Statistics Field of Research (FoR) codes aggregate the sub-disciplines below into a single four-digit code (0202):

020201 Atomic and Molecular Physics
020202 Nuclear Physics
020203 Particle Physics
020204 Plasma Physics; Fusion Plasmas; Electrical Discharges
020299 Atomic, Molecular, Nuclear, Particle and Plasma Physics not elsewhere classified.

Atomic, Molecular, Nuclear and Plasma Physics have (by-and-large) similar publication and citation modalities. However, they are grouped in the 0202 category along with Particle Physics, which has strikingly different publication practices.

Particle physicists often publish papers with hundreds of co-authors, and as a result the citation level is extremely high. This has two effects. It increases the international benchmark performance for the sub-discipline, and therefore for the 0202 aggregate. Second, it skews the ranking of any group that has one or more members collaborating in the publication.

One can try to normalise the result using international relative citation indices, but that doesn't help because particle physicists are few and far between. The result is that a Unit of Evaluation (UoE) that includes particle physicists will boost the ranking of that UoE above the average, while those with no particle physicists will fall below the average.

The 'Particle Physics' effect is evident in the 0202 ERA rankings, where Sydney, Melbourne and Adelaide top the 0202 categories: Each of these departments has a significant presence in Particle Physics.

It is also noteworthy that no Australian institution ranks at the highest level (5) in the 0202 category, perhaps because of the absence of a major Particle Physics facility in this country. This may also explain why the 0202 FoR code is the only Physics code that ranks just below world average.

We have written to the ARC Excellence in Research committees regarding the 0202 code and they are well aware of the issue. Short of changing the FoR codes (which is done infrequently by the ABS to enable useful longitudinal comparisons), it will require the subjective evaluation of 0202 performance data by the ERA committees with the above knowledge in mind.

Sincerely,

Professor Ken Baldwin
Deputy Director
Research School of Physics and Engineering
Australian National University
Canberra, ACT

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But it might unless you subscribe now!
You'd think that in 2012 we'd be spared prophecies of Armageddon, but these predictions are just the tip of the asteroid.
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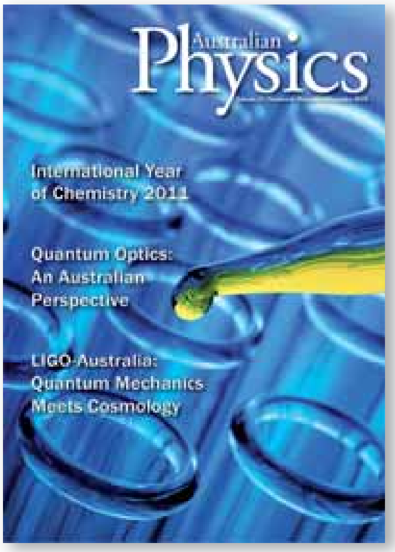


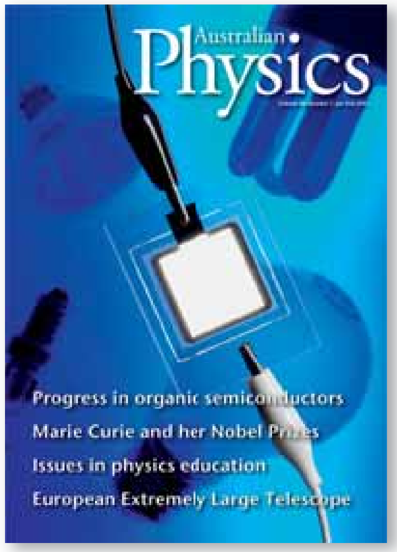


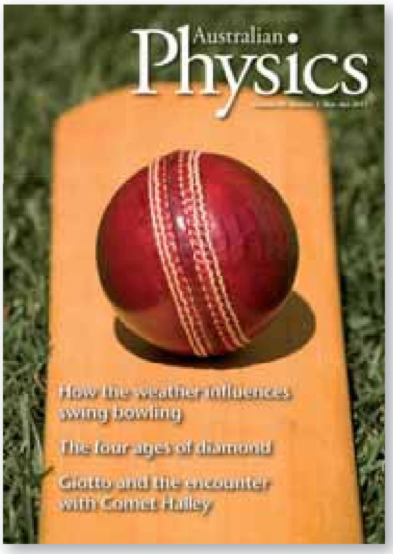


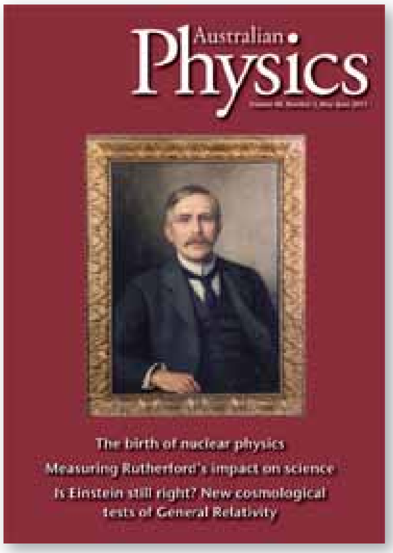


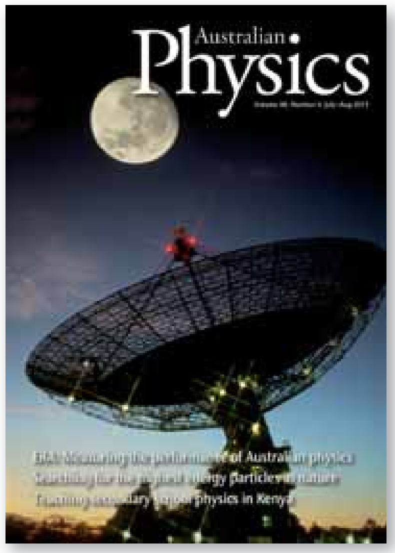


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# Australian Physics

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## ANU astronomer wins Nobel Prize

Professor Brian Schmidt from the Research School of Astronomy and Astrophysics at the Australian National University has won the 2011 Nobel Prize for Physics. Announced in Stockholm on Tuesday, 4 October, the award is shared with two US scientists – Professor Adam Riess from Johns Hopkins University and Professor Saul Perlmutter from the University of California, Berkeley. The award is for the discovery that the Universe is expanding at an accelerating rate.

Perlmutter will receive one half of the 10 million Swedish kroner ($A1.5 million) prize, with Schmidt and Riess sharing the other half. It is the first time in almost 100 years that an Australian has won a Nobel Prize for Physics. In 1915 the father and son team William and Lawrence Bragg were awarded the Physics prize for their development of X-ray crystallography.

Schmidt's breakthrough was made while he led the High-*Z* SN Search Team, which included Riess. Formed by Schmidt in 1994, the research team examined distant supernovae to measure the rate at which the Universe was moving apart. Professor Perlmutter researched the same field as part of a separate project. Perlmutter's team included the prominent Australian astronomers Dr Brian Boyle (CSIRO) and Professor Warwick Couch (Swinburne University of Technology). In 1998 both teams discovered that the Universe is speeding up as it expands, rather than slowing down as previously thought.

The announcement drew worldwide attention to Schmidt, including a call from the White House. The next day he met with the Prime Minister, conducted thirty media interviews and taught a cosmology class. Ms Gillard praised Schmidt and his research team, saying the award would make all Australians proud. "It is another day on which Aussie researchers make Australians proud," said the Prime Minister.

The award has also attracted widespread praise from the field of science. Professor Suzanne Cory, president of the Australian Academy of Science, said Schmidt's work had a profound and immediate effect on cosmology. "Previously, it had been thought that the expansion of the universe was slowing, or proceeding at a steady rate. Astrophysicists say the finding that the expansion is in fact accelerating has completely altered our understanding of the Universe and opened up important new fields in the study of time and dark energy," she said.

The ANU community is also celebrating Schmidt's award, the sixth Nobel Prize to be won by an ANU researcher since the University's foundation in 1946. ANU Vice-Chancellor Professor Ian Young said Schmidt's work had changed the face of astronomy.

**Stuart Wyithe (left), Brian Schmidt and Bryan Gaensler (University of Sydney) at the PM's science awards ceremony held at Parliament House in Canberra in October. Wyithe was awarded the 2011 Malcolm McIntosh Prize for Physical Scientist of the Year, only a few days after Schmidt's Nobel Prize was announced [courtesy: Stuart Wyithe].**

"The ANU community is overjoyed to hear the news that Brian Schmidt has won the Nobel Prize for Physics," he said. "His work has helped to unveil a Universe that, to a large extent, was unknown to science. He has shown that what we see in the skies is but a tiny fraction of what is really out there. Brian reminds us of the infinite mysteries yet to be understood. ANU congratulates a great man and celebrates his magnificent achievement."

Born in the US, Schmidt came to the Mt Stromlo Observatory at the ANU in 1995 after completing his PhD at Harvard. He is now working on the SkyMapper telescope, a new wide field survey telescope located at the Siding Spring Observatory, that will conduct the most detailed study ever of the southern sky.

In addition to this week's Nobel Prize, in 2000 Schmidt was awarded the Australian Government's in-

augural Malcolm McIntosh award for achievement in the Physical Sciences, the Pawsey Medal in 2001 by the Australian Academy of Sciences, the Vainu Bappu Medal in 2002 by the Astronomical Society of India, and an Australian Research Council Federation Fellowship in 2005.

In 2006 Schmidt was jointly awarded the US$1 mill Shaw Prize for Astronomy, and in 2007 he shared the US$0.5 mill Gruber Prize for Cosmology with his High-*Z* SN Search Team colleagues.

When not star-gazing, Brian Schmidt enjoys a second career as a winemaker and owns a successful vineyard on the outskirts of Canberra.

## Barry Inglis Medal and NMI Prize

At a ceremony held on 5 September at the National Measurement Institute, Lindfield NSW, the Barry Inglis Medal for 2011 was awarded to Dr Philip Nakashima and the NMI Prize to Dr Michael J. Biercuk.

**Philip Nakashima** is a Research Fellow of 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. His research is focussed on measuring atomic and electronic structure in materials (mainly metals) by electron diffraction.

Nakashima obtained first class honours in Physics and Materials Engineering from the University of Western Australia and, in 2003, received his PhD with distinction in Physics from the same university. Philip's research interests include electron scattering theory, transmission electron microscopy, quantitative image processing and analysis, accurate structure determination and metals physics.

**Dr Philip Nakashima.**

The nature of bonding between atoms in metals – the metallic bond – is a vaguely understood phenomenon in materials science. In some metals, such as aluminium, the electrons are so weakly localised that the term 'free electron gas' is applied. This concept is useful for

## Malcolm McIntosh Prize for 2011

For his work on the physics of the formation of the Universe, Professor Stuart Wyithe (University of Melbourne) has received the Malcolm McIntosh Prize for Physical Scientist of the Year.

At the age of 300,000 years after the Big Bang, the Universe became a cold dark place, with no galaxies, no stars and no light. A billion years later nuclear fusion lit up the Universe as hydrogen atoms clumped to form stars and galaxies.

Our best telescopes can see the light of the early galaxies, but how did the first stars and galaxies form? What triggered the cosmic dawn? What happened during the billion-year Dark Age? Wyithe's theories may lead to some of the answers.

Wyithe grew up in the Blue Mountains where, away from the bright lights of Sydney, the night sky had meaning. At secondary school, he was involved in an astronomy club run by a keen teacher. After initially enrolling in chemical engineering at university, he quit after two years to go travelling. When he returned, he finished an honours degree in physics at the University of Melbourne and immediately enrolled for a PhD in astrophysics.

After his first year, Stuart took advantage of a visitor program to go to Princeton, initially for a semester. That was the last Australia saw of him for several years. He completed his doctorate at Princeton, and then he moved to Harvard University as a NASA Hubble Fellow.

Professor Edwin Turner of the Princeton University Observatory notes: "Stuart and I are co-authors of 15 papers of which 11 were submitted during his graduate school years. It is clear that he is an exceptionally energetic and efficient worker. The quality of his work is no less impressive." Wyithe has now published over 100 papers, five of which have appeared in the prestigious journal *Nature*.

**Dr Michael Biercuk.**

loosely explaining certain phenomena such as electrical, thermal and acoustic conductivities, but its usefulness ends there. Over the past eighty years or so, efforts to measure the degree and form of metallic bonding in the best example of a free electron gas – aluminium – have failed partly because the electrons are so weakly localised and partly because of physical limitations associated with conventional experiments.

A new approach to electron diffraction has been developed by Nakashima and applied to make the first unequivocal measurements of metallic bonds in aluminium. A number of important physical characteristics of aluminium, such as mechanical strength and alloying phenomena, can now be explained directly in terms of the accurate picture of metallic bonding gained from these measurements. This knowledge provides a new and fundamental basis for understanding the production of commercial alloys and their industrial processing routes.

**Michael Biercuk** is an experimental physicist at the University of Sydney where he holds a continuing teaching and research appointment. He was educated in the US, with his undergraduate degree from the University of Pennsylvania, and his Master's and PhD degrees from Harvard University.

After conducting postdoctoral research in trapped ion quantum information at the National Institute of Standards and Technology, Biercuk moved to Sydney in 2010 to establish the Quantum Control Laboratory.

The ability to detect small forces is at the heart of many modern technologies including advanced spin-resonance and microscopy techniques. The detectors providing this capability are mostly based on tiny, vibrating mechanical beams which respond to very slight disturbances from external forces. As nanofabrication techniques have improved and device dimensions have shrunk, we have seen improved performance from these mechanical oscillators. In a new development Biercuk's group employs atomic ions trapped using

Wyithe's recent work has focused on the evolution of the structure of the Universe. He notes: "Astronomy is all about trying to understand how the Universe came to look the way it does, as well as how it works. What's not understood is how the galaxies themselves formed. This is inexorably linked with the transition from a Universe of cold, uncharged, atomic hydrogen to being ionised and hot. This 'Epoch of Reionisation' is the last non-understood event in the history of the Universe."

"The obvious candidate for the energy that drove this process is the formation of stars, and that is where most attention has been focused." Another possible source is the formation of supermassive black holes. And it is in these two possibilities that Wyithe has been most interested.

"The reason that Stuart's work has had so much impact", says Professor Matthew Colless, Director of the Australian Astronomical Observatory, "is that not only does it elucidate a fundamentally important epoch in cosmic evolution, but it has also focused on making explicit, detailed and testable predictions for the large-scale structures that should be observed. These predictions strongly suggest that there are rich observational signatures of the Epoch of Reionisation just beyond the limit of current facilities."

Wyithe now chairs the science committee for the Murchison Widefield Array, a revolutionary new telescope being constructed by a US–Australia–India consortium in Western Australia. It will test some of the ideas to be incorporated into the Square Kilometre Array.

Wyithe was once considered to be Australia's top rock climber though, with a young family, he has cutback on this activity. He was recently awarded an ARC Australian Laureate Fellowship [see *AP* **48**(5), 135].

electromagnetic fields as ultra-sensitive mechanical oscillators approaching the ultimate scaling limits of sensor technology.

Through the development of new measurement techniques for trapped ions, the Quantum Control Laboratory has demonstrated systematic force-detection sensitivity over 1000 times better than previous approaches. The results realised force detection sensitivity in the yoctonewton regime – where yocto ($=10^{-24}$) is the smallest defined SI prefix.

Biercuk's research has also addressed the speed with which a measurement can be performed and may spark interest in a new generation of atom-based sensing devices with applications in research and the mining and defence industries.

## The Dish Turns Fifty

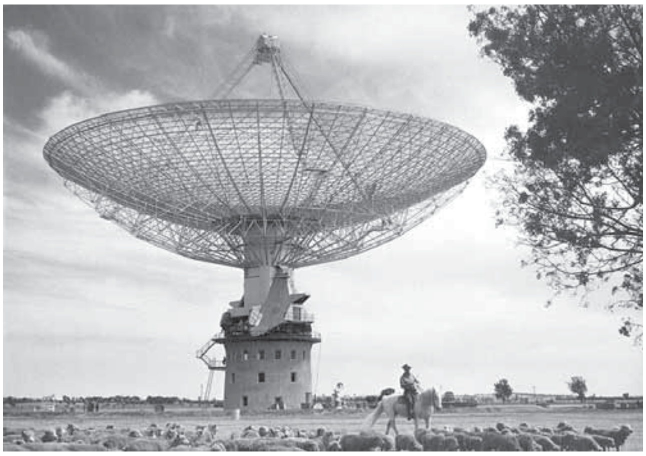
The Dish – CSIRO's 64-m radio telescope at Parkes in NSW – threw open its doors to the public on the weekend of 8 & 9 October. The Open Days featured free telescope tours, talks, exhibits and children's activities. Dr Megan Clark, CSIRO chief executive, and Dr Phil Diamond, chief of CSIRO Astronomy and Space Science (CASS), spoke at a ceremony to commemorate the telescope's 50th anniversary.

The telescope, located 20 km north of the Parkes township, was inaugurated on 31 October 1961. The telescope is probably best known for its role in receiving the television signals of the Apollo 11 Moon landing in July 1969, as popularised in the film 'The Dish' first screened in October 2000.

"Parkes is still one of the best-performing radio telescopes in the world", said Phil Diamond, who was recently appointed chief of CASS after being director of the famous Jodrell Bank dish near Manchester.

The telescope played a crucial role in the discovery of quasars and in determining their nature. The Dish has discovered over one-half of the 2000 known pulsars, more than all of the world's radio telescopes put together. Recently it discovered the first binary pulsar system, which is expected to lead to the most stringent tests of General Relativity.

Repeated upgrades have made the telescope 10,000 times more sensitive than when it was opened on a blustery day in 1961. Its surface panels, focus cabin, receiving equipment, pointing system, control panel and data processors have all been replaced – in most cases more than once. "The telescope is like a council worker's broom – it's had three new handles and two new brushes, but it's still the same broom", Dr Diamond said.



**Iconic image – the Parkes dish shortly before its inauguration on 31 October 1961. On horseback is Austie Helm who sold part of his farm to CSIRO to provide a site for the telescope. [courtesy: National Library of Australia]**

"The standout new technology has been the multibeam – that is, multipixel – receiver that allows the telescope to see more of the sky at once", he said. "This has been the mainstay of much of what Parkes has achieved in recent years."

Planning for the telescope began in 1954, and built on Australia's world leadership in the new field of radio astronomy. Half the funding came from the US Carnegie and Rockefeller foundations and the other half from the Australian government. It was designed by the British firm of Freeman Fox (which earlier had designed the Sydney Harbour Bridge). It was constructed by the German firm MAN.

NASA used the Parkes dish as its model in designing and building its series of dishes that form the Deep Space Network, one of which is located at Tidbinbilla near Canberra.

"Three generations of scientists have explored the Universe with Parkes", said Phil Diamond. "The Dish is an icon of Australian science."

The celebrations at Parkes concluded with a symposium held during the first week of November.

# A Nobel Week

Stephen Luntz

**Brian Schmidt's world was turned upside-down when he was awarded the 2011 Nobel Prize for Physics for research that has turned our understanding of the Universe inside out.**

Prof Brian Schmidt has lost count of the number of interviews he conducted in the week after the announcement that he had won the 2011 Nobel Prize for Physics. The media office at the Australian National University, where Schmidt is professor of astronomy, estimates it at 150. At least 16,000 articles were published worldwide during that time. In addition Schmidt suddenly found himself invited to meet the Prime Minister and give public lectures.

While Schmidt is full of praise for the ANU media office, which took over his diary soon after the prize was announced, they have not been able to lighten his teaching load, which he describes as the largest obstacle to meeting the sudden rush of requests. He is, he says, "still waiting for an opportunity to think".

Schmidt did manage to squeeze an interview with *Australasian Science* into his agenda, albeit after the intensity of the first rush had passed. We benefited from Schmidt's positive memories of an article he wrote for our themed issue on astronomy (*AS*, Jan/Feb 2009, pp.12–14), which has suddenly become an auspicious edition; Schmidt's opening feature was followed by an article by Stuart Wyithe (*AS*, Jan/Feb 2009, pp.15–18), who won the 2011 Malcolm McIntosh Prize for Physical Scientist of the Year a few days after Schmidt's Nobel Prize was announced.

As many of the 16,000 articles have noted, the Nobel Prize came as a surprise to Schmidt, although he says he had a fair idea when a call from a woman with a Swedish accent asked him to stand by for a very important phone call.

The Nobel Prize was awarded for Schmidt's role in the discovery that the expansion of the Universe is accelerating. Since gravity inevitably acts to pull the Universe's matter together, it had been assumed that the parting of galaxies must be happening at a decreasing rate. The crucial question was considered to be whether gravity would prove strong enough to eventually reverse this expansion, causing everything to collapse again.

Schmidt, along with Prof. Adam Reiss of Johns Hopkins University, measured the brightness of Type 1a supernovae, which all produce similar amounts of light. With the intrinsic and observed brightness known it is possible to calculate the stars' distances. The rate of movement away from us was found using the established technique of measuring the red shift of emission lines in the object's spectra.

Putting the idea into practice, however, required the discovery of a substantial number of 1a supernovae, which had only been observed rarely. However, Schmidt and Reiss realised that advances in telescope and instrument design made this possible.

"During the course of a night these telescopes can survey more than a million galaxies and find tens of supernovae," Schmidt wrote in *Australasian Science*. "Since 1994 astronomers have found more than 500 exploding stars scattered from the present to 11 billion years ago."

To their astonishment Schmidt and his colleagues found "that the Universe has been speeding up for the past six billion years rather than slowing down". The publication of this finding in 1998 led to the revival of Einstein's briefly proposed idea of a form of matter called dark energy that repels itself, balancing gravity. Further examination of the data led to the conclusion that the Universe is actually 75% dark energy, with the other 25% made up of a combination of the matter we

can actually see and the more traditional dark matter.

The Nobel's science prizes cannot be shared between more than three people, so the other winner of the 2011 Physics Prize is Prof Saul Perlmutter of the Lawrence Berkeley National Laboratory, who led a competing team conducting a similar supernovae search, with each team publishing within a few weeks of the other.

Schmidt is keen for everyone to be aware that the discoveries were very much a team achievement. "There were 18 other people on the team," he says. "You don't have to name them all, but I want to get out the idea they were important."

Schmidt, Reiss and Perlmutter shared the Shaw Prize for Astronomy in 2006 and the Gruber Cosmology Prize in 2007. Nevertheless, prizes other than the Nobels do not make scientists famous. For a day after the announcement, typing "Brian Schmidt" into Wikipedia produced the page of a composer of music for pinball and video games, with a link at the top to the apparently less interesting astrophysicist. This has since been reversed.

Some Nobel Prize winners have been woken by the phone call, and had to confront the media still half-awake. Schmidt had more luck, being called at 8:30 pm and given 10 minutes to make a comment on the official announcement. "The first call came from *ABC Lateline*, who asked if they could come out and visit me," Schmidt recalls. In fact, a film crew was already on its way, despite having only a vague idea of where Schmidt lives.

Meanwhile the phone did not stop ringing. Eventually Schmidt called the ANU media office and asked if someone could take over screening his calls. Schmidt adds: "They'd been calling to offer but couldn't get through".

Schmidt was up until 1:30 am answering calls before going to bed. His father, a fisheries biologist in Anchorage, Alaska, where Schmidt went to high school, called at 2:30 am. "I didn't take the call but it woke me up," Schmidt says. By the time he started his first morning interviews at 6:45 am he'd had 2 hours sleep.

Schmidt also received a supportive call from Prof. Barry Marshall, winner of the 2005 Nobel Prize for Medicine, who "gave me his sense of things". Nevertheless, he certainly felt under pressure. "You're only one sentence away from disaster with the media the way it is."

In the course of the following days Schmidt met not only the Prime Minister and Science Minister but also the Finance Minister. Ten days after the announcement he flew to Hawaii for a meeting of the committee that oversees the Gemini Telescopes, on which he serves. Two public talks were added to the schedule, so it was "a more intense trip than usual".

For some winners the Nobel Prize is a door to research opportunities for which they could never previously get funding, but that is not the case for Schmidt. "I'm in the middle of a huge project for the next 5–7 years. I don't need anything more. For that period I just want to focus on Skymapper, making a map of the entire southern sky, identifying locations for the really interesting things we want to come back and study in detail with Gemini South and the Anglo-Australian Telescope."

On the other hand the status of the Prize, and the fact that millions of people now know his name, gives Schmidt a platform. "I think I have a responsibility to try to ensure that Australia and the world understand how science works and why it is important," Schmidt says. "I don't want to mix science and policy, but I have been pushing for the Academy of Science to articulate scientific positions on issues of relevance. In the US this is a formalised role for the academies, and I'd love to see that here."

Schmidt was asked to speak at the awarding of the Prime Minister's Science Prizes, where he sat next to Prime Minister Julia Gillard. "I tried to remind people that Australia has gone from being far away from the rest of the developed world to being on the edge of areas where development is happening. We should be raising expectations of ourselves," Schmidt says.

"I hope we raise our education expectations commensurate with our wealth so that science can be the engine of prosperity when the commodity boom is over. I want to make people aware of how important science is; how universities and CSIRO make the world a better place."

His message to those assembled for the PM's Prizes could not have been missed by Gillard or her advisers. "I often hear it said that science and education policy never won an election. But nations rise and fall on the outcomes of science and education.

"The lack of political acknowledgement of this may be because science and education do not run on a 3-year cycle. It takes decades for such policies to run their course, but they provide a similarly long legacy – 12 years of good education provides a 50-year legacy."

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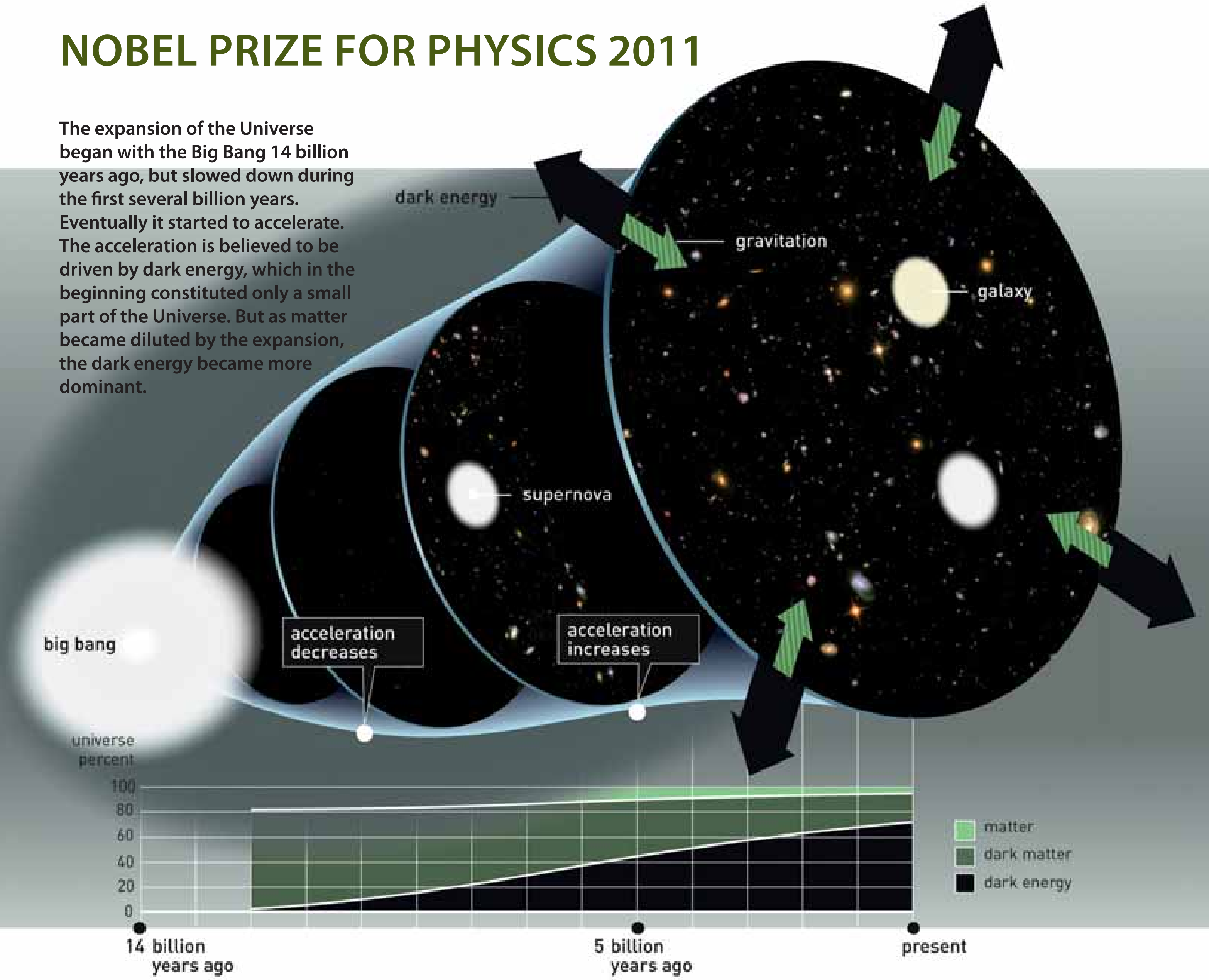
**Stephen Luntz is a writer for *Australasian Science* magazine (see p.167). This interview first appeared in the December 2011 issue. I am most grateful to the editor of *Australasian Science*, Guy Nolch, for permission to reproduce the interview here – Ed.**

## NOBEL PRIZE FOR PHYSICS 2011




**The expansion of the Universe began with the Big Bang 14 billion years ago, but slowed down during the first several billion years. Eventually it started to accelerate. The acceleration is believed to be driven by dark energy, which in the beginning constituted only a small part of the Universe. But as matter became diluted by the expansion, the dark energy became more dominant.**

# Written in the Stars


## The Royal Swedish Academy of Sciences


‘Some say the world will end in fire; Some say in ice…’
Robert Frost, *Fire and Ice*, 1920

**What is the fate of the Universe? Probably it will end in ice if we are to believe this year’s Nobel Laureates. They have carefully studied several dozen exploding stars, called supernovae, in faraway galaxies and have concluded that the expansion of the Universe is speeding up.**

The discovery came as a complete surprise even to the Nobel Laureates themselves. What they saw would be like throwing a ball up in the air, and instead of having it come back down, watching as it disappears more and more rapidly into the sky, as if gravity could not manage to reverse the ball's trajectory. Something similar seemed to be happening across the entire Universe.

**"The two research teams raced each other to map the Universe by finding the most distant supernovae."**

The growing rate of the expansion implies that the Universe is being pushed apart by an unknown form of energy embedded in the fabric of space. This dark energy makes up a large part of the Universe, more than 70%, and it is an enigma, perhaps the greatest in physics today. No wonder then that cosmology was shaken at its foundations when two different research groups presented similar results in 1998.

Saul Perlmutter headed one of the two research teams, the Supernova Cosmology Project, initiated a decade earlier in 1988. Brian Schmidt headed another team of scientists, which towards the end of 1994 launched a competing project, the High-*Z* Supernova Search Team, in which Adam Riess was to play a crucial role.

The two research teams raced each other to map the Universe by finding the most distant supernovae. By establishing the distance to the supernovae and the speed at which they are moving away from us, the two groups hoped to reveal our cosmic fate. They expected to find signs that the expansion of the Universe was slowing down, which would lead to equilibrium between fire and ice. What they found was the opposite – the expansion was accelerating.

## Cosmos is growing

It is not the first time that an astronomical discovery has revolutionised our ideas about the Universe. Only a hundred years ago, the Universe was considered to be a calm and peaceful place, no larger than our own galaxy, the Milky Way. The cosmological clock was ticking reliably and steadily and the Universe was eternal. Soon, however, a radical shift would change this picture.

At the beginning of the 20th century the American astronomer Henrietta Leavitt found a way of measuring distances to faraway stars. At the time, women astronomers were denied access to the large telescopes, but they were frequently employed for the cumbersome task of analysing photographic plates. Leavitt studied thousands of pulsating stars, called Cepheids, and found that the brighter ones had longer pulses. Using this information, Leavitt could calculate the intrinsic brightness of Cepheids. If the distance of just one of the Cepheid stars is known, the distances to other Cepheids can be established – the dimmer its light, the farther away the star. A reliable standard candle was born, a first mark on the cosmic yardstick that is still used today.

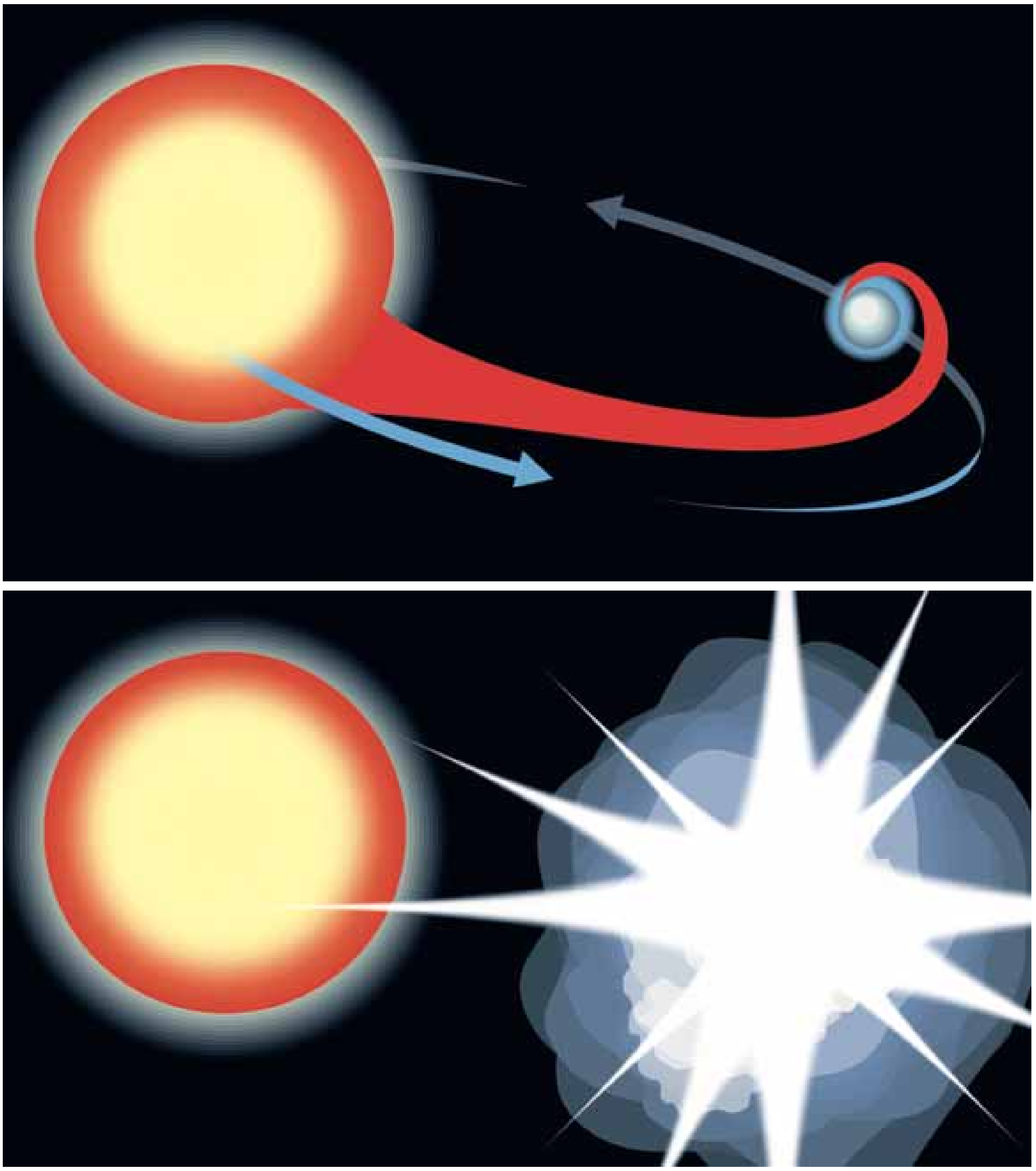
By making use of Cepheids, astronomers would soon conclude that the Milky Way is just one of many galaxies in the Universe. In the 1920s Edwin Hubble, using the world's largest telescope on Mount Wilson in California, studied the so-called redshift that occurs when a source of light is receding from us. The conclusion was that the galaxies are rushing away from us and each other, and the farther away they are, the faster they move – this is known as Hubble's law.

## The coming and going of the cosmological constant

What was observed in space had already been suggested by theoretical calculations. In 1915 Albert Einstein published his General Theory of Relativity, which has been the foundation of our understanding of the Universe ever since. The theory describes a Universe that has to either shrink or expand.

This disturbing conclusion was reached about a decade before the discovery of the ever-fleeing galaxies. Not even Einstein could reconcile the fact that the Universe was not static. So in order to stop this unwanted cosmic expansion, Einstein added a constant to his equations that he called the cosmological constant. Later, Einstein would consider the insertion of the cosmological constant his biggest mistake. However, with the observations made in 1997–98 that are awarded this year's Nobel Prize, we can conclude that Einstein's cosmological constant – put in for the wrong reasons – was actually brilliant.

The discovery of the expanding Universe was a ground-breaking first step towards the now standard view that the Universe was created in the Big Bang almost 14 billion years ago. Both time and space began



A white dwarf draws gas from its neighbour and when it has grown to 1.4 solar masses, it explodes as a type Ia supernova.

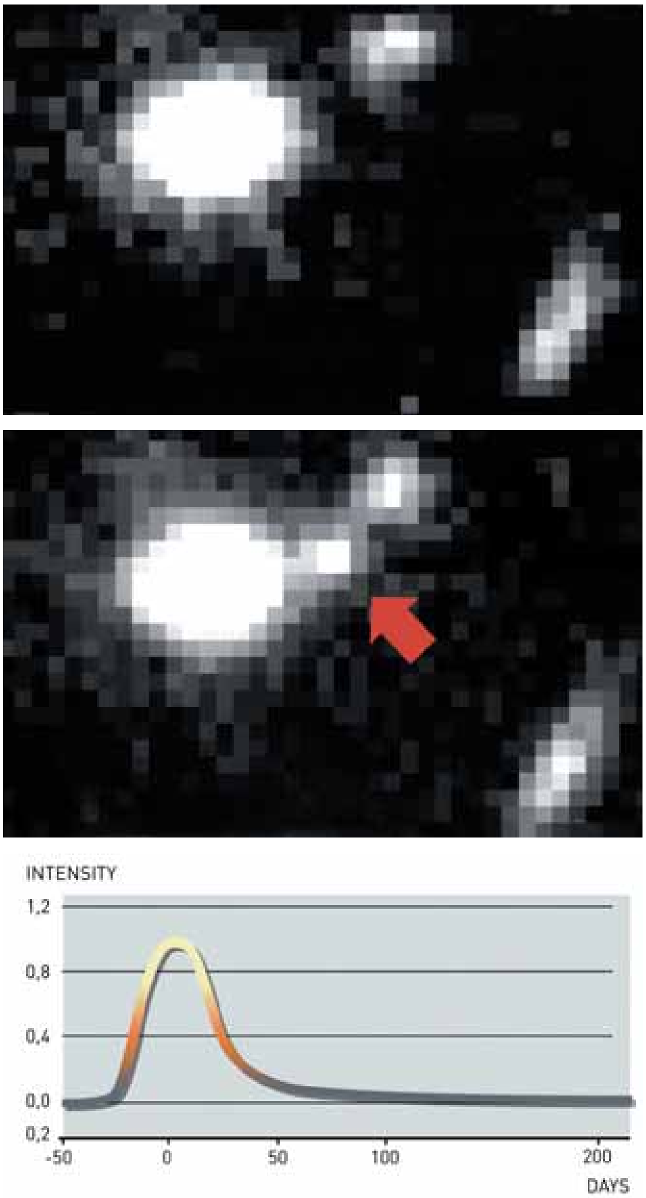
then. Ever since, the Universe has been expanding; galaxies are moving away from each other due to the cosmological expansion. But where are we heading?

## Supernovae – the new measure of the Universe

When Einstein got rid of the cosmological constant and surrendered to the idea of a non-static Universe, he related the geometrical shape of the Universe to its fate. Is it open or closed, or is it something in between – a flat Universe? An open Universe is one where the gravitational force of matter is not large enough to prevent the expansion of the Universe.

All matter is then diluted in an ever larger, ever colder and ever more empty space. In a closed Universe, on the other hand, the gravitational force is strong enough to halt and even reverse the expansion. So the Universe eventually would stop expanding and fall back together in a hot and violent ending, a Big Crunch. Most cosmologists, however, would prefer to live in the most simple and mathematically elegant Universe: a flat one, where the expansion is believed to decline. The Universe would thus end neither in fire nor in ice. But there is no choice. If there is a cosmological constant, the expansion will continue to accelerate, even if the Universe is flat.

This year's Nobel Laureates expected to measure the cosmic deceleration, or how the expansion of the Universe is slowing. Their method was in principle the same as the one used by astronomers more than six




**Supernova 1995ar. Two images of the same area of sky taken three weeks apart. In the second image, the small dot of light was discovered and its status as a type Ia supernova was established after further observations of its light curve. The light curve is the same for all type Ia supernovae and most light is emitted during the first few weeks.**

decades earlier: to locate distant stars and to measure how they move. However, that is easier said than done. Since Henrietta Leavitt's days many other Cepheids have been found that are even farther away. But at the distances that astronomers need to see, billions of light-years away, Cepheids are no longer visible. The cosmic yardstick needed to be extended.

Supernovae became the new standard candles [Ed: see Fig. 2 in the article by Chris Blake in *AP* **48**(5), 149–53 (2011)]. More sophisticated telescopes on the ground and in space, as well as more powerful computers, opened the possibility in the 1990s to add more pieces to the cosmological puzzle. Crucial were the light-sensitive digital imaging sensors – charged-coupled devices or CCD – the invention by Willard Boyle and George Smith who were awarded Nobel Prize for Physics in 2009.

## White dwarfs exploding

The newest tool in the astronomer's toolbox is a special kind of star explosion, the type Ia supernova. During a few weeks, a single such supernova can emit as much light as an entire galaxy. This type of supernova is the explosion of an extremely compact old star that is as heavy as the Sun but as small as the Earth – a white dwarf. The explosion is the final step in the white dwarf's life cycle.

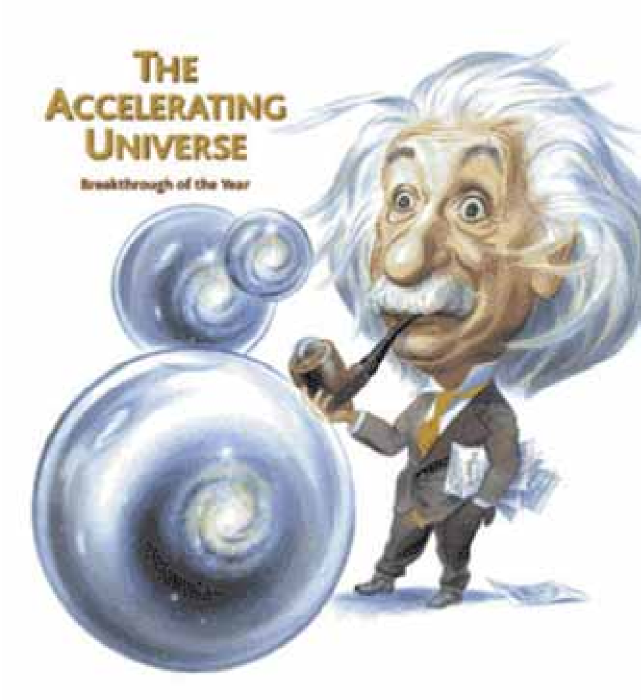
White dwarfs form when a star has no more energy at its core, as all hydrogen and helium have been burned in nuclear reactions. Only carbon and oxygen remain. In the same way, far off in the future, our Sun will fade and cool down as it reaches its end as a white dwarf.

A far more exciting end awaits a white dwarf that is part of a binary star system, which is fairly common. In this case, the white dwarf's strong gravity robs the companion star of its gas. However, when the white dwarf has grown to 1.4 solar masses, it no longer manages to hold together. When this happens, the interior of the dwarf becomes sufficiently hot for runaway fusion reactions to start, and the star gets ripped apart in seconds.

The nuclear fusion products emit strong radiation that increases rapidly during the first weeks after the explosion, only to decrease over the following months. So there is a rush to find supernovae – their violent explosions are brief. Across the visible Universe, about ten type Ia supernovae occur every minute. But the Universe is huge. In a typical galaxy only one or two supernova explosions occur in a thousand years. In September 2011, we were lucky to observe one such supernova in a galaxy close to the Big Dipper, visible just through a pair of regular binoculars. But most supernovae are much farther away and thus dimmer. So where and when would you look in the canopy of the sky?

## An astounding conclusion

The two competing teams knew they had to comb the heavens for distant supernovae. The trick was to compare two images of the same small piece of the sky,




**The accelerating expansion of the Universe was proclaimed 'Breakthrough of the Year' in the December 1998 issue of the journal *Science* [volume 282, number 597]. On the cover, Albert Einstein gazed upon his cosmological constant, which has returned to the forefront of cosmology [credit: John Kascht and *Science*].**

corresponding to a thumbnail at arm's length. The first image has to be taken just after the new moon and the second three weeks later, before the moonlight swamps out starlight. Then the two images can be compared in the hope of discovering a small dot of light – a pixel among others in the CCD image – that could be a sign of a supernova in a galaxy far away. Only supernovae farther than a third of the way across the visible Universe were used, in order to eliminate local distortions.

The researchers had many other problems to deal with. Type Ia supernovae are not quite as reliable as they initially appeared – the brightest explosions fade more slowly. Furthermore, the light of the supernovae needed to be extracted from the background light of their host galaxies. Another important task was to obtain the correct brightness. The intergalactic dust between us and the stars changes starlight. This affects the results when calculating the maximum brightness of supernovae.

Chasing supernovae challenged not only the limits of science and technology but also those of logistics. First, the right kind of supernova had to be found. Second, its redshift and brightness had to be measured. The light curve had to be analysed over time in order to be able to compare it to other supernovae of the same type at known distances. This required a network of scientists that could decide quickly whether a particular star was a worthy candidate for observation. They needed to be able to switch between telescopes and have observation time at a telescope granted without delay, a procedure that usually takes months. They needed to act fast because a supernova fades quickly. At times, the two competing research teams discreetly crossed each other's paths.

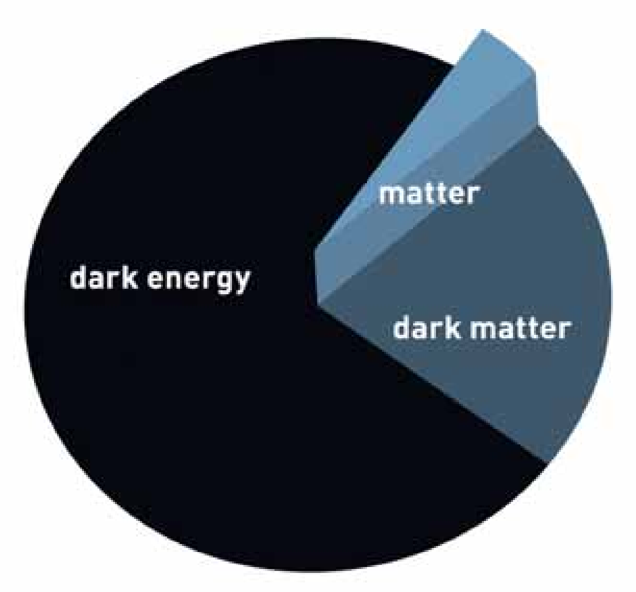
The potential pitfalls had been numerous, and the scientists actually were reassured by the fact that they had reached the same amazing results: all in all, they found some 50 distant supernovae whose light seemed weaker than expected. This was contrary to what they had envisioned. If cosmic expansion had been losing speed, the supernovae should appear brighter. However, the supernovae were fading as they were carried faster and faster away, embedded in their galaxies. The surprising conclusion was that the expansion of the Universe is not slowing down – quite to the contrary, it is accelerating.

## From here to eternity

So what is it that is speeding up the Universe? It is called dark energy and is a challenge for physics, a riddle that no one has managed to solve yet. Several ideas have been proposed. The simplest is to reintroduce Einstein's cosmological constant, which he once rejected. At that time, he inserted the cosmological constant as an anti-gravitational force to counter the gravitational force of matter and thus create a static Universe. Today, the cosmological constant instead appears to make the expansion of the Universe to accelerate.

**"During a few weeks, a single supernova can emit as much light as an entire galaxy."**

The cosmological constant is, of course, constant, and as such does not change over time. So dark energy becomes dominant when matter, and thus its gravity, gets diluted due to expansion of the Universe over billions of years. According to scientists, that would account for why the cosmological constant entered the scene so late in the history of the Universe, only five to




**The implication of the discovery is that three quarters of the Universe is an unknown form of dark energy. Together with equally unknown dark matter, the dark energy constitutes 95% of the Universe.**

six billion years ago. At about that time, the gravitational force of matter had weakened enough in relation to the cosmological constant. Until then, the expansion of the Universe had been decelerating.

The cosmological constant could have its source in the vacuum, empty space that, according to quantum physics, is never completely empty. Instead, the vacuum is a bubbling quantum soup where virtual particles of matter and antimatter pop in and out of existence and give rise to energy. However, the simplest estimation for the amount of dark energy does not correspond at all to the amount that has been measured in space, which is about $10^{120}$ times larger. This constitutes a gigantic and still unexplained gap between theory and observation – on all the beaches of the world there are no more than $10^{20}$ grains of sand.

> **"... the findings of the 2011 Nobel Laureates in Physics have helped to unveil a Universe that is 95% unknown to science."**

It may be that the dark energy is not constant after all. Perhaps it changes over time. Perhaps an unknown force field only occasionally generates dark energy. In physics there are many such force fields that collectively go by the name quintessence, after the Greek name for the fifth element. Quintessence could speed up the Universe, but only sometimes. That would make it impossible to foresee the fate of the Universe.

Whatever dark energy is, it seems to be here to stay. It fits very well in the cosmological puzzle that physicists and astronomers have been working on for a long time. According to current consensus, about three quarters of the Universe consist of dark energy. The rest is matter. But the regular matter, the stuff that galaxies, stars, humans and flowers are made of, is only 5% of the Universe. The remaining matter is called dark matter and is so far hidden from us.

The dark matter is yet another mystery in our largely unknown cosmos. Like dark energy, dark matter is invisible. So we know both only by their effects – one is pushing, the other one is pulling. They only have the adjective 'dark' in common.

Therefore the findings of the 2011 Nobel Laureates in Physics have helped to unveil a Universe that is 95% unknown to science. And everything is possible again.

## Credits

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Additional information on this year's Prize, including a 19-page scientific background article in English, may be found at the website of the Royal Swedish Academy of Sciences, kva.se, and at nobelprize.org. The latter also includes web-TV versions of the press conferences at which the awards were announced.

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# 50 Years of Manned Spaceflight
## *A Brief History*

**Jonathan Nally**

**"Let's go!" With those words, spoken by Yuri Gagarin at T-0 on 12 April 1961, the world changed forever. As the Soviet cosmonaut thundered skyward aboard the Vostok 1 spacecraft, a new era in exploration had dawned. For the first time, humankind had left the safe and comforting bosom of mother Earth and ventured into the unknown blackness of space.**

**Soviet cosmonaut Yuri Gagarin was the first person to reach outer space, during the flight of Vostok 1 on 12 April 1961.**

Gagarin's single orbit stunned and enthralled the world. It was true – a human could survive and operate beyond the atmosphere. For billions of years, all life on Earth had been confined to a shallow habitat that spanned from just below the planet's surface to some way up into its atmosphere. But no longer. Twentieth-century technology had explosively boosted our species' range to new heights.

So you'd think that, 50 years later, the exploitation of this new frontier would be in full swing. But it isn't. It's still in its infancy. Although a lot has been achieved, there is still a long way to go – but the roadmap is becoming perhaps somewhat easier to read.

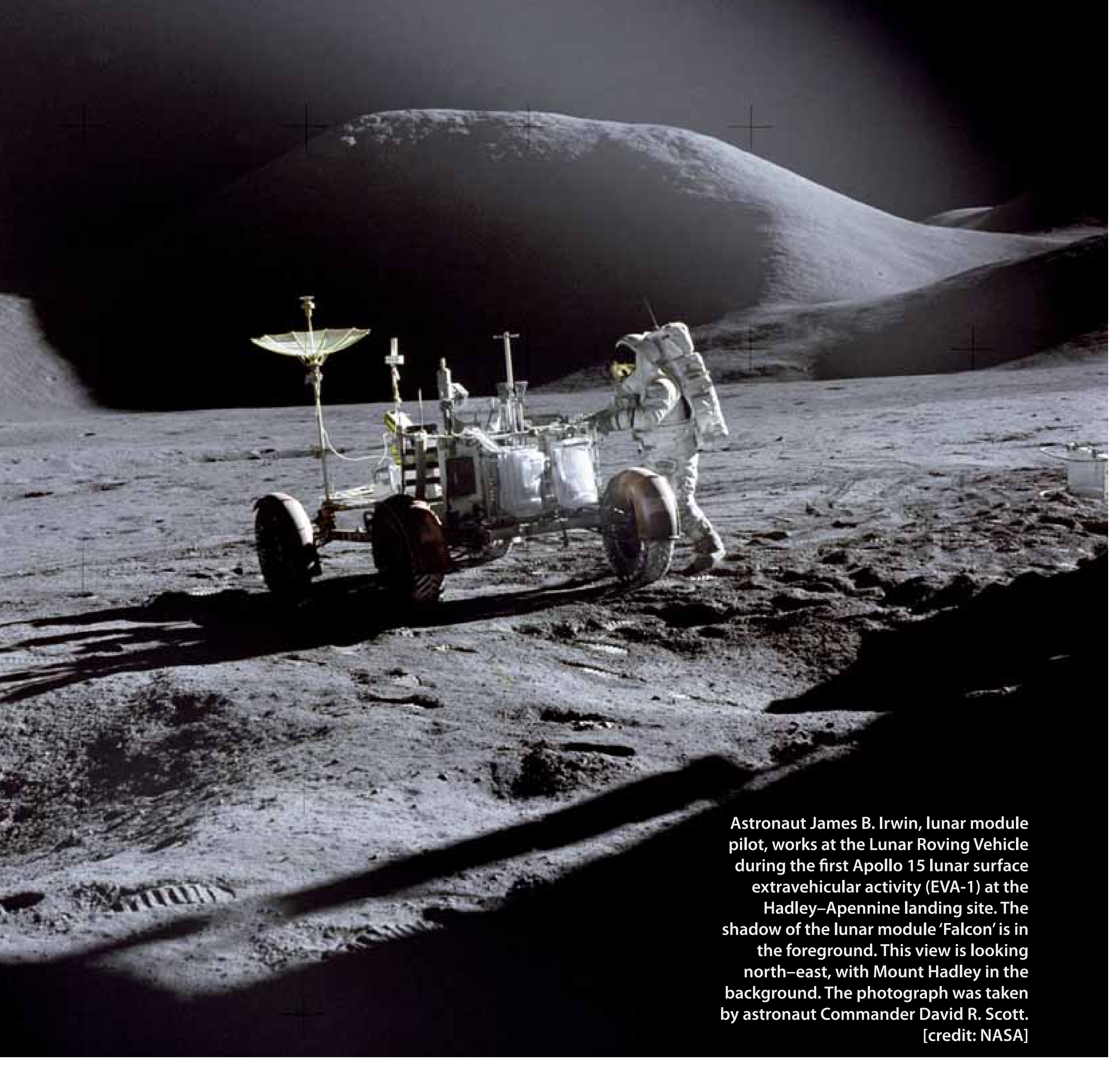
### The race begins

Gagarin's flight, followed less than a week later by the abortive Bay of Pigs invasion of Cuba, put the USA firmly on the back foot. At this point, with the Cold War in full swing, John F. Kennedy had been president for less than three months and the Soviet's repeated successes were taking their toll on American morale and prestige. Kennedy decided the USA had to respond with something big, something daring… something they had a chance of winning.

Calling in his advisers, he asked what could be done to beat the Soviets. What about space? That was the new frontier. What could be done there? What about all this talk of space stations or flying to the Moon? Could we do that? Rapid consultations with a handful of engineers in the nascent NASA (the agency that had been formed less than three years earlier) came up with the answer – a manned mission to the Moon and back was technically feasible within about 10 years, although the technologies and techniques did not then exist.

And so it was that on 25 May 1961, Kennedy announced plans for a lunar mission: "I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to the Earth. No single space project in this period will be more impressive to mankind, or more important in the long-range exploration of space; and none will be so difficult or expensive to accomplish."

It's worth remembering that by this point, the USA



Astronaut James B. Irwin, lunar module pilot, works at the Lunar Roving Vehicle during the first Apollo 15 lunar surface extravehicular activity (EVA-1) at the Hadley–Apennine landing site. The shadow of the lunar module 'Falcon' is in the foreground. This view is looking north–east, with Mount Hadley in the background. The photograph was taken by astronaut Commander David R. Scott. [credit: NASA]

**"Kennedy decided the USA had to respond with something big, something daring... something they had a chance of winning."**

had made only one manned spaceflight – Alan Shepard's 15-minute sub-orbital lob. America had committed itself to a lunar landing before it had even put a person into orbit. It was a high-risk gamble upon which the nation was embarking.

## The first 20 years

The rest, as they say, is history. The Apollo programme was a tremendous success, landing 12 men on the lunar surface and returning them safely to Earth. Even the failed Apollo 13 mission was considered a daring and triumphal accomplishment.

The Soviets, having realised they wouldn't win the Moon race, turned their attention to low-Earth orbit (LEO) operations, launching many crews into space and, in the early 1970s, the world's first space stations (the Salyut series). Their achievements were perhaps unspectacular but, like the hare and the tortoise, they plodded along and made continual progress.

The USA, with tough economic challenges, domestic


**Space shuttle Atlantis (STS-135) is rolled over to the Orbiter Processing Facility shortly after landing at NASA's Kennedy Space Center Shuttle Landing Facility, completing its 13-day mission to the International Space Station and the final flight of NASA's Space Shuttle Program on 21 July 21 2011, in Cape Canaveral, Florida. Overall, Atlantis spent 307 days in space and travelled nearly 126 million miles during its 33 flights. Atlantis, the fourth orbiter built, was launched on its first mission on 3 October 1985. [credit: NASA/Bill Ingalls]**

social upheaval and an intractable war in Vietnam, quickly tired of the space adventure. Facing potential oblivion at the beginning of the 1970s, NASA pushed for a new beginning in space, one that promised to reduce the cost but boost the returns – a reusable space shuttle, followed by a permanently manned space station. The space shuttle programme was approved by only the skin of its teeth, and only after the US Air Force decided to support it (but not with dollars). Development began immediately, with first flight planned for the late 1970s.

Meanwhile, using surplus Apollo hardware, the US launched Skylab, a very large space station aboard which crews would conduct scientific experiments in a range of disciplines. Three crews of three men visited the station in the early 1970s, gaining for NASA valuable insights into the challenges of conducting long-duration space missions. This was followed in July 1975 by the joint Soviet–US Apollo–Soyuz Test Project, a symbolic effort at détente in LEO. The two Soviet and US spacecraft docked in orbit and the crews spent an enjoyable few days conducting experiments and generally having a good time.

It was hoped that the space shuttle would be flying in time to deliver a rocket module to the mothballed Skylab, boosting it to a higher orbit for possible future use. But the shuttle became delayed, and Skylab's orbit eventually decayed and led to re-entry in 1979, with pieces of it falling over Western Australia. The first shuttle launch came on 12 April 1981, twenty years to the day since Gagarin's historic flight.

## Consolidation

The 1980s saw the Soviets continue investigations into long-duration spaceflight aboard their space stations, including Mir. Cosmonauts set longer and longer records for stays in space, and scientists learned a lot about the long-term effects of the microgravity environment on the human body.

For the USA, it was a new and exciting era as the space shuttle began flying, carting satellites and experiments into orbit. At first it seemed like the promise of

**The space shuttle Atlantis is seen over the Bahamas prior to a perfect docking with the International Space Station. Part of a Russian Progress spacecraft which is docked to the station is in the foreground. Atlantis was to make the final flight in the space shuttle programme. [credit: NASA]**

> **"The first shuttle launch came on 12 April 1981, twenty years to the day since Gagarin's historic flight."**

science fiction was coming true – regular flights using a spacecraft that could be turned around and flown again within a short span of time. But it soon became apparent that the original ambitions for frequent turnarounds were not being met, and costs were climbing.

Then in 1986 came the terrible tragedy of Challenger, a disaster all the more distressing for being foreseeable and preventable. The problem with the rubber seals in the joints between booster rocket segments had long been known, and the decision to launch on a day of freezing temperatures (when the rubber would be brittle) doomed the seven astronauts, destroyed a billion-dollar machine and set the US manned spaceflight programme back years.

Several policy changes were implemented, including the decision to no longer carry commercial satellite payloads (commercial pressure to launch was one of the factors cited in the Challenger case), and to not carry payloads that used a particular kind of booster rocket (now deemed too dangerous). The US military also gave up on the shuttle, and the launch tower it had built (but never used) in California was mothballed.

## The International Space Station

By the end of the 1980s, the superpower geopolitical situation had changed dramatically. The Soviet Union was collapsing, and the USA and Russia were exploring ways in which they could co-operate peacefully. One of the arenas chosen was spaceflight. For some time, the USA had been in the process of planning for a major space station that would have international input. With Russia now America's new best friend, NASA was directed to include them in their planning.

The result is the International Space Station (ISS), a hugely ambitious – and hugely expensive – multinational effort built around US and Russia cores. Con-

**The International Space Station is more than 100 metres long, more than 400 tonnes in weight and has an interior pressurised volume of around 1000 cubic metres. [credit: NASA]**

struction commenced in 1998 and is almost complete – the final major component will be the Russian Multipurpose Laboratory Module, scheduled for launch in 2012. Over 100 metres long, 417 tonnes in mass and around 1000 cubic metres in volume, the ISS is truly huge. It has 15 pressurised modules powered by 16 huge solar power arrays. Its crew of six is drawn from member states – so far it has hosted astronauts and cosmonauts from 15 nations.

The ISS has come in for a lot of criticism over the years, mainly to do with cost… and this criticism is not without merit. The Station has ended up being far more expensive than planned (no real surprise there) and many have argued that those funds could have been better and more effectively spent on unmanned facilities. That's probably so, but it bears remembering that full-scale operation has only just begun, so only time will tell if the money and effort has been worth it.

It is also worth remembering that manned spaceflight is undertaken not just for reasons of exploration and scientific endeavour – it's also a matter of national prestige and technology development. ISS operations are currently funded and approved through to the year 2020. It seems fairly unthinkable that this will be the limit of its lifetime – barely 10 years of full operation. It is most likely that its life will be extended, perhaps with contributions from new spacefaring nations, such as China, and maybe with input from and utilisation by private enterprise.

## End of the shuttle

For NASA, it must have seemed that everything was going so well. Construction of the ISS was proceeding smoothly, and shuttle operations had been routine for many years. Then came the horrifying disintegration of Columbia during re-entry in 2003, and the biggest shake-up in US manned spaceflight since the end of the Apollo era.

The post-Columbia review determined that the shuttles had become too long in the tooth and too unsafe to continue flying without hugely expensive safety upgrades. The decision was taken to make some safety improvements to prevent a repeat of Columbia's fate, and then to finish building the International Space Station as quickly as possible and pension the shuttles off. This would leave the US without a manned

## An International Endeavour

Many nations have launched unmanned satellites into space, including Australia with WRESAT in 1967, but only three have had the capability to launch humans into orbit. Between the Soviet's slow-and-steady approach, and the USA's somewhat more dramatic flights – plus now three manned flights by the Chinese with their Shenzhou craft – a total of 525 individuals from 38 nations have flown in space. Of these, 335 have been US citizens and 113 Soviet/CIS. The overall gender breakdown is 470 men and 55 women.

Inside the Kibo lab onboard the International Space Station (ISS) in May 2011. Twelve astronauts and cosmonauts making up the STS-134 Endeavour and ISS Expedition 27 crews take a break for a group portrait. From left in the front row are Paolo Nespoli (European Space Agency), Dmitry Kondratyev (Russia), Mark Kelly (NASA) and Roberto Vittori (ESA). Back row: Cady Coleman (NASA) and Russian cosmonauts Andrey Borisenko and Alexander Samokutyaev, along with NASA astronauts Ron Garan, Michael Fincke, Andrew Feustel, Greg Chamitoff and Greg H. Johnson. [credit: NASA]

**"Then came the horrifying disintegration of Columbia during re-entry in 2003, and the biggest shake-up in US manned spaceflight since the end of the Apollo era."**

spaceflight capability, and make it reliant on the Russians with their Soyuz capsule to get astronauts into orbit – not something that pleased everyone in Congress or the spaceflight community.

Artist's impression of the SpaceX Dragon capsule, intended to conduct supply runs to the International Space Station. [credit: SpaceX]

The USA needed a new vision for space exploration, and it was a case of back to the future – a plan to return to the Moon and eventually travel to Mars. To achieve this, a new crewed capsule would be needed, plus two new rockets… one to loft the capsule into orbit, and a bigger one to send it plus a lunar module to the Moon. The capsule was named Orion and the rockets Ares.

So NASA spent more than five years and the better part of $US10 billion developing the new systems, only to have the programme cancelled by the new Obama administration… one week before the first test launch of the first of the new Ares rockets.

This on again, off again approach to manned spaceflight has typified the US approach for the past two decades. The ISS – originally proposed as Space Station Freedom in 1983 – went through numerous wasteful redesigns in the 1980s and 1990s as Congress continually shuffled funding and changed the rules in mid-stream. But at least one good thing has come out of the end of the shuttle era and the cancellation of Orion… the realisation that much of the US's future in LEO should be turned over to private enterprise.

### The new frontier

The USA has decided to relinquish LEO manned transport to private ventures. In my opinion, this is a very good move. With the ISS built, America no longer needs the full capabilities of a space shuttle just to get crews into space. It simply needs someone to operate a taxi service, regularly, safely and inexpensively.

Aviation was very expensive in its early days – limiting its use to specialised services or to the very

wealthy – eventually the prices came down as new technologies made the cost per seat much lower. In the early days of the Kangaroo Route between Australia and the UK, the cost of a return ticket could have bought you a house – around 130 weeks of average wages. Today, a return ticket is about two weeks of average wages. The same reduction in costs is bound to happen with privately run spaceflight too.

And private enterprise has been quick to see the potential for exploiting LEO services. It is interesting to note that many (though not all) of those competing in the LEO race are recent entrants rather the traditional, old monolithic aerospace companies.

With some seed money from NASA, several operators are developing both unmanned and manned craft to supply the ISS. Prime among them is SpaceX, founded by Elon Musk, one of the inventors of PayPal. SpaceX has already had one very successful test flight of its Dragon unmanned cargo capsule, lofted into orbit atop SpaceX's own heavy-lift rocket, Falcon 9. Dragon's first operational flight to the ISS could come as early as November 2011.

A similar cargo capsule, Cygnus, is being developed by Orbital Sciences Corporation with the first test flight scheduled for late 2011. Then there is Sierra Nevada Corporation, developing the Dream Chaser, a spaceplane that could carry up to eight people into LEO. Boeing is working on the CST-100, a reusable Apollo-like capsule that could carry seven astronauts.

And the secretive Bigelow Aerospace is working on inflatable space stations – two 'scale models' have been operating in orbit for several years. Meanwhile, NASA is pushing ahead with a modified version of Orion, intended to be able to undertake deep space missions – initially to a near Earth asteroid, and eventually to Mars.

The shift to commercialisation of LEO transport services has been a long time coming, and it promises two key benefits. First, it will drive launch and operational costs down, as competition leads to innovation and 'lean' business models. And secondly, and perhaps more importantly, it will free up precious public funding. Space agencies such as NASA are at their best when they apply their limited resources to pushing into unknown frontiers, exploring new horizons and inventing the technologies of tomorrow. It is high time that private enterprise took over the bus service into LEO, letting national space programmes concentrate on going boldly where they've never gone before.

**Artist's impression of the Orbital Sciences Corporation unmanned Cygnus spacecraft about to dock with the International Space Station. [credit: Orbital Sciences Corporation]**

**"With the ISS built, America no longer needs the full capabilities of a space shuttle just to get crews into space. It simply needs someone to operate a taxi service, regularly, safely and inexpensively."**

## AUTHOR BIO

**Jonathan Nally is a veteran science writer and broadcaster. He is a recipient of the David Allen Prize from the Astronomical Society of Australia for excellence in communicating astronomy to the public. He was the founder and editor of *Sky & Space*, Australia's first popular-level astronomy magazine, and currently is editor of the Australian astronomy and space news website: www.spaceinfo.com.au.**

# OBITUARY

## Trevor Tansley (1943 – 2011)

### Deb Kane, Macquarie University

Trevor Lionel Tansley arrived in Australia in 1976 to take up a lectureship in physics at Macquarie University in Sydney. He retired 31 years later having made many contributions, including high impact research in semiconductor materials and physics, and higher degree research education. He is remembered with affection as an erudite and cultivated man; a skilled communicator, a diplomat, and a supervisor par excellence to more than 50 research students.

Trevor was born in Leicester, England during WWII. He was educated at Gateway Boys' Grammar School, Leicester 1954–61, and completed a Physics Honours degree at the University of Sheffield in 1961–64. He was recruited directly to the Mullard Research Laboratories (MRL), Surrey, a part of the Philips Research Laboratory Group, where he engaged in semiconductor materials and device research. Tunnelling phenomena in semiconductors and the heterostructure were recent discoveries. He has ten single author papers on his heterojunction research from 1966–67 alone, all published in prestigious journals.

Trevor completed a PhD at Nottingham University as an external student while working at MRL. A highlight of his early career was co-chairing a session at the first International Conference on the Physics and Chemistry of Semiconductor Heterojunctions with Leo Esaki (who later shared the 1970 Nobel Prize for Physics). In 1974 Trevor successfully applied for a fellowship in the Department of Electrical and Electronic Engineering at Nottingham University, where he achieved the first known sputter deposition of luminescent ZnO on Si.

After Trevor and his family emigrated to Australia, he taught widely in physics and electronics and was quickly promoted to senior lecturer in 1977. He remained motivated and energetic to make new opportunities for frontline semiconductor materials growth, characterisation, and theory research. Supervising PhD students facilitated this. His re-emergence onto the international stage was via research on indium nitride with Don Neely and Cathy Foley. A 1986 paper, 'Optical band gap in indium nitride', by Tansley and Foley in *J. Appl. Phys.* remains his most highly cited work with almost 500 citations. This research established Trevor as one of the visionaries for the significance and importance of nitride semiconductor research. Colleagues, such as Chenupatti Jagadish at the ANU, have acknowledged that "Trevor is important internationally as a pioneer of nitride research".

Trevor authored or co-authored 176 journal papers. He established the Semiconductor Science and Technology Laboratories at Macquarie University in the early 1990s, which grew to about 25 staff. The success in nitride semiconductor research ultimately led to BluGlass Pty Ltd to commercialise Macquarie University IP developed from ARC funded research on remote plasma chemical vapour deposition.

Trevor was appointed as Professorial Fellow and the Foundation Dean of Graduate Studies at Macquarie University in 1996. He had many international research collaborations and held external positions around the world. He was awarded a DSc by Nottingham University and was elected a Fellow of the IEE, both in 1995.

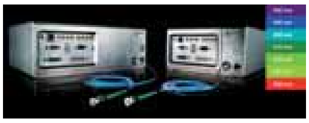
**[credit: Michelle Wilson]**

Trevor is a remembered as a rare and delightful man, and an excellent friend to many in the international physics and electronic engineering communities. He is survived by his wife Sarah and nine children and stepchildren. He is buried alongside his eight-year old son Francis.

**[Trevor's life is described more fully at www.aip.org.au/news/239, along with information on how to donate to the 'Professor Trevor Tansley Prize'.]**

## LASTEK–TOPTICA PHOTONICS

### Multi-Colour Systems – Multi-Laser Engines and Tunable VISible Lasers



Three exciting new systems are now available from Toptica:

**iChrome MLE-L**
Multi Laser Engine with up to three diode lasers and one DPSS laser fully integrated in one compact box.
- Multi-line laser with up to four laser lines
- Wavelengths diode lasers: 405, 445, 488 and 640 nm (375, 473, 660, 785 nm and others on request)
- Wavelengths DPSS laser: 532 and 561 nm (505, 515, 594 nm and others on request)

**iChrome MLE-S**
All-diode Multi Laser Engine with up to four diode lasers fully integrated in one compact box.
- Multi-line laser with up to four diode laser lines
- Available wavelengths: 405, 445, 488 and 640 nm (375, 473, 660, 785 nm and others on request)
- High free-space and fibre coupled output power levels

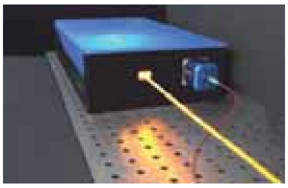
**Common to both MLE models**
The individual lasers are efficiently combined and delivered free beam or via an all-in-one PM/SM fibre output. The microprocessor controlled system enables flexible OEM integration. High-speed analogue and digital modulations allow fast switching of laser wavelength and intensity.

TOPTICA's ingenious COOL$^{AC}$ technology automatically aligns the system with a single push of a button. This feature ensures a constant optical output level even under strongly varying ambient conditions and completely eliminates the need for manual realignment – making the iChrome MLE the most advanced multi-line laser system on the market.
- Single mode, polarisation maintaining fibre output or free beam COOL$^{AC}$ technology for highest coupling efficiency, ultimate stability and drop-shipment capability
- Direct modulation and fast switching between wavelengths
- True one-box solution with integrated electronics
- Unique features: COOL$^{AC}$, FINE and SKILL technology
- Most compact and cost effective solution for multicolour biophotonic applications

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

The iChrome TVIS laser system is a fibre laser with the flexibility to set automatically the laser output to any wavelength in the visible (488–640 nm). The coherent laser output ensures that the visible light exhibits the best intensity noise performance and the use of polarisation maintaining optical components a stable linear polarisation of the fibre coupled output beam is achieved. The entire laser system is extremely user friendly: No alignment procedures of any optical components distract the user from the main task – to produce results.

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



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

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

### FemtoFiber pro – the product family is expanded

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

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

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

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

**For more information please contact Lastek at sales@lastek.com.au**
**Lastek Pty Ltd**
**Adelaide University – Thebarton Campus**
**10 Reid St, Thebarton, SA 5031**
**Aus 1800 882 215; NZ 0800 441 005**
**Tel: +61 8 8443 8668 Fax: +61 8 8443 8427**
**e-mail: sales@lastek.com.au Web: www.lastek.com.au**

# WARSASH SCIENTIFIC

## Lightweight Benchtop Vibration Isolation

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

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

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

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

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

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

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

## Real-Time Operating System for Systems Integration

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

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

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

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

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

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

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

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

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

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

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

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

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

**For more information on these and the range of other PI products, contact sales@warsash.com.au.**
**Warsash Scientific Pty Ltd**
**Tel: +61 2 9319 0122 Fax: +61 2 9318 2192**
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## COHERENT SCIENTIFIC

## Introducing the new SG384 4GHz RF Signal Generator

The SG384 uses a unique, innovative architecture (Rational Approximation Frequency Synthesis) to deliver ultra-high frequency resolution (1 μHz), excellent phase noise, and versatile modulation capabilities (AM, FM, øM, pulse modulation and sweeps) at a fraction of the cost of competing designs.

Features:

- DC to 4.05 GHz
- 1 μHz resolution
- AM, FM, øM, PM and sweeps
- OCXO timebase (std)
- -116 dBc/Hz SSB phase noise (20 kHz offset, f = 1 GHz)
- Rubidium timebase (opt.)
- Square wave clock outputs (opt.)
- Analog I/Q inputs (opt.)
- Ethernet, GPIB and RS-232 interfaces

The standard model SG384 produces sine waves from DC to 4.05 GHz. There is an optional frequency doubler (Opt 02) that extends the frequency range to 8.10 GHz. Low-jitter differential clock outputs (Opt 01) are available and an external I/Q modulation input (Opt 3) is also offered. For demanding applications, the SG384 can be ordered with a rubidium time base (Opt 04).

## Stanford Research Systems Photon Counter

The SR400 Dual-Channel Gated Photon Counter from Stanford Research Systems offers a convenient, integrated approach to photon counting that avoids the complexity and expense of old counting systems. No longer is it necessary to mix and match amplifiers, discriminators, gate generators and counters. The SR400 combines all these modules into a single, integrated, microprocessor controller instrument. Complete measurement tasks such as background subtraction, synchronous detection, source compensation and pile-up correction can all be performed easily with the SR400.

Features:

- Two independent counting channels
- Count rates to 200 MHz
- 5 ns pulse-pair resolution
- Gated and continuous modes
- Gate scanning for time-resolved counting
- Built-in discriminators
- Gate and discriminator outputs
- GPIB and RS-232 interfaces.

## Stanford Research Systems Multichannel Scaler

The SR430 is the first multichannel scaler which combines amplifiers, discriminators, bin clocks, and data analysis in a single, integrated instrument. With its many features and its easy-to-use menu driven interface, the SR430 simplifies time-resolved photon counting experiments. The SR430 Multichannel Scaler/Averager can be thought of as a photon counter that counts events as a function of time. A trigger starts the counter which segments photon count data into sequential time bins (up to 32k bins). The width of the bins can be set from 5 ns to 10 ms. The instrument records the number of photons that arrive in each bin.

Features:

- 5 ns to 10 ms bin width
- Count rates up to 100 MHz
- 1k to 32k bins per record
- Built-in discriminator
- No interchannel dead time
- On-screen data analysis
- Hardcopy output to printers/plotters
- DOS compatible 3.5-inch drive
- GPIB and RS-232 interfaces.

## Coherent Inc EnergyMax Laser Sensors

EnergyMax-USB/RS sensors contain miniaturised meter electronics that are integrated within the sensor cable. Coherent's entire range of high performance EnergyMax sensors are available in this form factor with either RS-232 or USB 2.0 connectivity enabling measurement of the energy per pulse or average power of pulsed lasers from the nanojoule to the multi-joule level, over wavelengths from the deep ultraviolet through the far infrared, and from single pulses to repetition rates of 10 kHz (with measurement of every pulse). Additionally, multiple EnergyMax sensors can share a trigger (internal or external) for synchronised operation, such as to enable pulse ratiometry.

Features:

- EnergyMax-USB/RS sensors provide USB connectivity for R&D and production environments, and USB 2.0 for OEM embedded applications
- Low cost of ownership

- Fast 16-bit A/D converter supports measurement accuracy similar to that found in LabMax-TOP meter
- Ability to log every pulse at data rates up to 10 kHz directly to a file
- Truly synchronised dual unit operation to support ratiometry >1 kHz every pulse
- State-of-the-art EnergyMax Sensor Technology.

**For further information on all four products, please contact Margaret Davies: sales@coherent.com.au.**
**Coherent Scientific**
**116 Sir Donald Bradman Drive, Hilton, SA 5033**
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**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

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

**14 – 16 February 2012**
**Pathways to SKA Science in Australasia**
SKANZ Conference, Auckland, New Zealand

**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

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TOPTICA PHOTONICS

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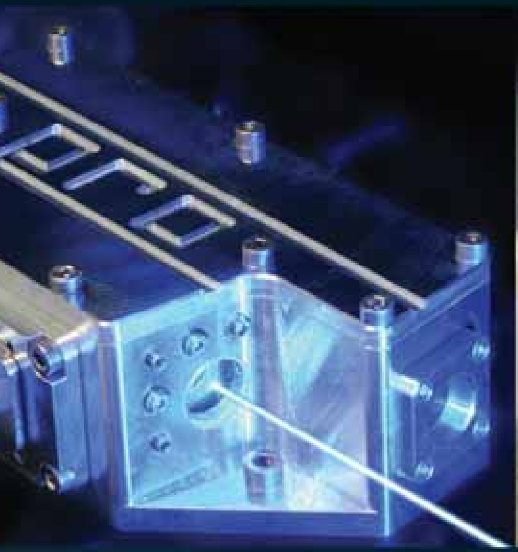

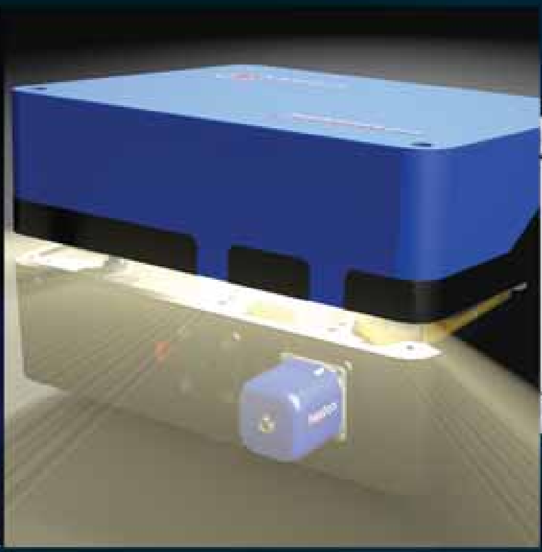


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- DL/TA-SHG/FHG pro
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