Australian Physics

Volume 48, Number 4, July–Aug 2011

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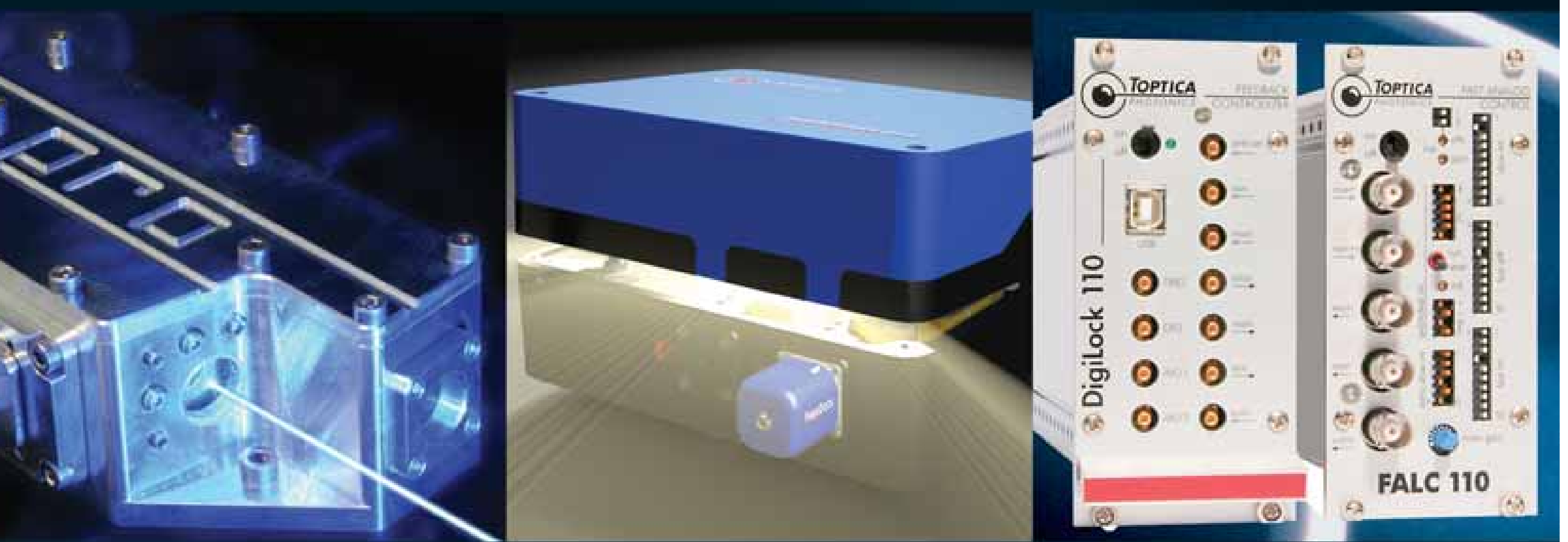

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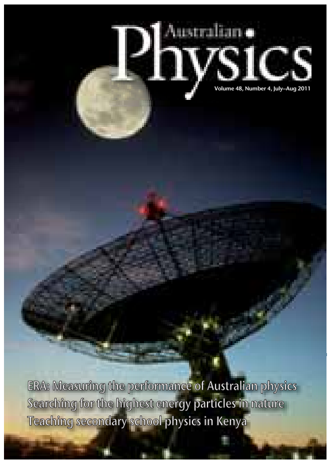

Cover
A double exposure created by Seth Shostak (SETI Institute, California). The image was created in 1996 at the beginning of the LUNASKA project at the Parkes telescope – see the article by Clancy James on page 109 [courtesy: Seth Shostak and Helen Sim (Australia Telescope National Facility, CSIRO)].

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EDITORIAL

Happy birthday Parkes

The Parkes Radio Telescope celebrates the 50th anniversary of its inauguration on 31 October this year, a remarkable feat. The instrument is arguably the most successful instrument ever built in Australia. It is also surely the most recognised piece of scientific hardware by the Australian public, thanks partly to the film *The Dish*, released in 2000, a wonderful dramatisation of the part the telescope played in the Apollo 11 moonwalk in July 1969.

The telescope is of course not the same instrument that it was in 1961. Its brilliant design has allowed constant renewal and improvement to its surface, receivers, electronics and computers, making Parkes still one of the leading and most productive radio telescopes in the world. As testimony to the continuing importance of Parkes, our cover story by Clancy James – the AIP Bragg medallist for 2010 – details the attempt to discover the origin and source of the most energetic particles in the universe.

To celebrate the 50th anniversary there will be an Open Days held at the telescope early in October, followed by a week-long conference for past and present astronomers during the first week of November. We wish the 'Grand Old Lady' of Australian science a very happy birthday.

We also feature in this issue an article by Frank Larkins that analyses the performance of physics departments in Australian universities during the recent Excellence in Research for Australia (ERA) exercise. Frank is a retired chemist, but one who is exceptionally well qualified to comment on Australian physics. His analysis shows that almost all of the physics departments that made submissions to ERA were rated equal to, or above, world standard in their particular discipline areas.

To close this issue Mathew Creese, a physics graduate from the ANU, recounts his experience of visiting Kenya and volunteering to teach physics at a local secondary school. It makes us proud that Australian physics is producing young people of his calibre.

Peter Robertson

Correction

In our recent article on the Giotto probe [*AP* **48**(2), 54 (2011)], we referred to the 'Russian Chernobyl nuclear power plant accident'. The city of Chernobyl is of course in The Ukraine.

PRESIDENT'S COLUMN

The training value of large-scale scientific infrastructure

The front cover of this issue and the 50th anniversary of the Parkes radio telescope made me think back to my own postgraduate days. I was mid-way through my PhD and my supervisor, John Greenhill, was concerned about getting enough X-ray data from annual 24 hour balloon flights to the top of the atmosphere. We had already had one launch failure losing a full year. The opportunity arose to observe the same celestial X-ray sources at radio wavelengths using the Parkes telescope. This broadened my study significantly but also ensured plenty of data in two disparate wavelength bands. We were searching for variable radio sources consistent in position with the carefully chosen X-ray source candidates. Of course, radio variability was something of a heresy in those days but there had already been conclusive observations of Circinus X-1 and some transients. We were to observe at 2 cm wavelength for which there was only an approximate pointing solution so we agreed to make the necessary measurements to improve the pointing solution and received substantially more observing time as a result. We made a number of discoveries and provided an improved pointing solution for the 2 cm receiver system. In the end the radio wavelength research made up half my PhD thesis.

So why, you might ask, am I spending so much of my column on a personal reminiscence? Working at the Parkes telescope in the late 1970s, less than ten years after it was involved with the moon landing and with many of the same systems, was an amazing experience for a PhD student. Not only did I get to work with a fantastic instrument which had been maintained and improved to remain state of the art, but I also got to work with some great astronomers and to meet a very much larger group of observers from across Australia and around the globe who had been allocated time just prior to or following our various multi-day observing sessions. These researchers were studying a wide range of astronomical phenomena. It was an unparalleled opportunity to be exposed to a broad range of scientific problems, an equally wide range of researchers from very different institutions and the full arsenal of radio astronomy detection techniques, theories and concepts by the people who were doing the work.

I look back today and recognise the fantastic training ground that such large infrastructure facilities provide for several generations of researchers. Later I saw the same opportunities for postgraduates with the *Aurora Australis* ice breaker (for oceanographic, southern ocean ecology and sea ice studies and their relationship to climate change), the Lucas Heights reactor and more recently the synchrotron to mention just a few. Of course we also hope that the SKA will be located in WA in the not too distant future. All these large-scale facilities provide ground-breaking new science but they do so much more. They nourish generations of young scientists in their postgraduate training and in their early careers and are part of the scientific culture of an advanced society such as ours.

The threat of losing one of these icons of our scientific culture, the synchrotron, due to a lack of committed funding beyond 2011–12 is thus an enormous concern both for the outstanding science over such a diverse range of disciplines that is and will continue to be done and for the loss of opportunity for our young scientists to cut their teeth on this world leading facility.

On behalf of the AIP and after discussion within the Executive and others I wrote to the Premier of Victoria expressing the AIP's concerns at the lack of funding commitment for the future operations of the facility. I am pleased to say that this week I received an encouraging reply from Premier Baillieu that showed he valued the facility and that negotiations between the state and federal governments and other agencies are under way. Let us hope that these negotiations are successful and that the opportunities many of us have had to train and work with cutting edge large-scale instruments and the additional intangible benefits they bring will continue to be provided in Melbourne for a long time to come.

Marc Duldig

LETTER

On absorbed, equivalent and effective radiation doses

Dear Editor,

I was motivated by John MacFarlane's letter in a previous edition of *Australian Physics* [**47**(5), 100 (2011)] to write on the SI units of absorbed, equivalent and effective dose. John lamented feeling 'in the dark' on the Gray and the Sievert, having been raised on the rem and the rad. I trust the following will illuminate…

The *absorbed dose D* from ionising radiation is defined as the amount of energy deposited in material per unit mass of the material. The SI unit of absorbed dose is the Gray (Gy) and 1 Gy = 1 J/kg. Our American colleagues (and colleagues of a certain vintage) frequently refer to the rad as the unit of absorbed dose. Note that 1 rad = 0.01 Gy (or 1 cGy).

In the field of radiation protection, the absorbed dose is only part of the picture. The *equivalent dose* H_T accounts for different radiation qualities exhibiting different biological effects. For example, an absorbed dose of 1 Gy from neutrons has a greater relative biological effect than 1 Gy from X-rays. The equivalent dose is the sum of the product of absorbed dose and the 'radiation weighting factor' W_R, or more formally,

$$H_{\mathrm{T}} = \sum DW_{\mathrm{R}}$$

The SI unit of equivalent dose is the Sievert (Sv), although the mSv (1×10^{-3} Sv) and μSv (1×10^{-6} Sv) are more frequently used in radiation protection. The rem, like the rad, is an old, non-SI unit still in use and 1 rem = 0.01 Sv. The radiation weighting factor for X-rays, γ-rays and electrons is unity, therefore the absorbed dose is numerically and physically the same as the equivalent dose, for these radiation qualities.

The *effective dose E* is another important radiation protection quantity and takes into account the equivalent dose and the relative sensitivity of the organ or tissue being irradiated. Bone marrow and the gonads are more radio-sensitive than skin or bone for example. More formally, the effective dose is

$$E = \sum H_{\mathrm{T}} W_{\mathrm{T}}$$

The SI unit of effective dose is also the Sievert (Sv). The tissue weighting factors W_T are used to estimate the proportion of damage to a tissue or organ relative to a whole body irradiation. The W_T factor is unity in the case of whole body irradiation and effective dose is numerically the same as equivalent dose.

Some examples may give the reader a better 'feel' for the typical dose ranges in radiation protection: The average, annual effective dose to humans from both naturally occurring and man-made radiation is about 0.0035 Sv, or 3.5 mSv. This dose is often termed 'background radiation'. The average dose *rate* for background radiation therefore is about 0.1 μSv/hour. Now, a chest X-ray deposits a dose of about 50 μSv; roughly the same as an airplane flight from New York to London. Some CT scan procedures however deliver effective doses as high as 5 mSv.

The International Commission for Radiological Protection (ICRP) recommends an annual effective dose limit of 1 mSv to members of the public, and 20 mSv to occupational workers from man-made sources of radiation. These limits do not apply to patients undergoing diagnostic or therapeutic procedures using radiation. Importantly, the effective dose is used to estimate the probability of so-called stochastic effects; a radiation-induced cancer or other genetic effect.

In his letter, John Macfarlane mentioned the nuclear crisis at the Fukushima power plant in Japan. The International Atomic Energy Agency (IAEA) produces regular reports on radiological monitoring in and around the Fukushima region and is perhaps the most reliable source of information. In the days following the disaster, the measured dose rate (attributed mainly to gamma rays) was of the order of 50 μSv/hr at the edge of the evacuation zone, approximately 30 km from the facility. This dose rate is 500 times the background dose rate of 0.1 μSv/hr mentioned above. Time, distance, and shielding bring this dose (and dose rate) back to background levels quite rapidly. The measured dose rate at the gates of the Fukushima plant were reported to be about 0.6 mSv/hr, meaning a member of the public would reach their annual dose limit in under two hours.

The websites of the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), the IAEA, and the ICRP provide further information, recommendations, and guidelines on ionising radiation units.

Sincerely,

Jeffrey C. Crosbie

University of Melbourne & The Alfred Hospital

New centre for engineered quantum systems

EQuS director Professor Gerard Milburn with research fellow Dr Uzma Akram.

Physicists at the new Australian Research Centre for Engineered Quantum Systems (EQuS) at the University of Queensland are taking steps on the road towards the quantum age. Following the lead from Nature, where photosynthesis uses quantum properties to be an efficient harvester of solar energy, researchers are aiming to engineer systems using these same quantum properties.

According to centre director Professor Gerard Milburn: "Quantum theory is the most successful theory of the physical world. Our understanding of the basic principles of quantum mechanics has produced the technology that shapes our daily lives; without it, there would be no computers, no smart phones and definitely no internet."

In the nineteenth century, inventor Charles Babbage envisaged a mechanical computer involving gears and cogs, but it could not be built with the technology then available. As it happened, computers were built from electrical technology not mechanical. Over 100 years later Babbage's vision, combined with the advances of computer-aided engineering, came to life (one is on display at the Science Museum in London).

Similarly, physicists understand the principles of quantum theory, but current technology lacks the ability to control the quantum world to their advantage.

New research centre at Macquarie

Director of the new Macquarie centre, Professor Quentin Parker.

The Macquarie Astronomy, Astrophysics and Astrophotonics Research Centre (MQRC AAA) was officially launched early in July. Lead by director Professor Quentin Parker, the new centre has ties to over 100 national and international universities, observatories, research institutions and commercial companies in 23 countries. This provides a solid network for effective multi-national collaborative research programs and partnerships with some of the world's leading institutions.

With its planned growth in research, the centre is predicted to soon be among the top four astronomy cohorts in Australia, alongside the Australian National University, the University of Sydney and Swinburne University.

Apart from many exciting mainstream astrophysics research programs and strong growth in the emerging field of cutting-edge astrophotonics, the centre has many other major projects already underway. One example is the Macquarie University-led $2.4 million ARC supported project 'Space to Grow', which combines astronomers with educational, ICT and science teaching experts to engage high school students in science using the hook of astronomy.

The new MQRC AAA will also have a strong focus on building links to the Indigenous community by engaging the Aboriginal Astronomy Research Group, a group dedicated to researching the astronomical knowledge and traditions of Indigenous Australians.

Director Quentin Parker has been overwhelmed with the support received in order to make this launch possible. "Thanks must go to Macquarie itself for so strongly supporting astronomy over the last eight years and allowing our potential to be realised. We must also thank the Australian Astronomical Observatory (AAO), our major external partner and the Australian Research Council whose support has been crucial to our spectacular growth", said Parker.

The collaborations that this new centre will encourage are expected to see a strong growth in the research outputs in astronomy, astrophysics and astrophotonics by Macquarie University in the future.

"We can see where we want to go but, like Babbage, lack the technological base from which to launch the journey. We first need to develop the ideas and techniques to build the technology", said Milburn.

This is the objective of EQuS, which is based at the University of Queensland with nodes at Macquarie University, the University of Sydney and the University of Western Australia.

What will the future of engineered quantum systems look like? Who can say, all we can do is reflect on how far we have come in the last 100 years. "It is the first small steps on the road to a quantum age. A journey started today allowing perhaps our grandchildren to become the technology entrepreneurs of the quantum age", said Professor Milburn.

Double solar cell record

A world record double by solar cell researchers at UNSW promises to make solar power more affordable, with world-beating new technology delivering substantial efficiency gains at minimal extra cost.

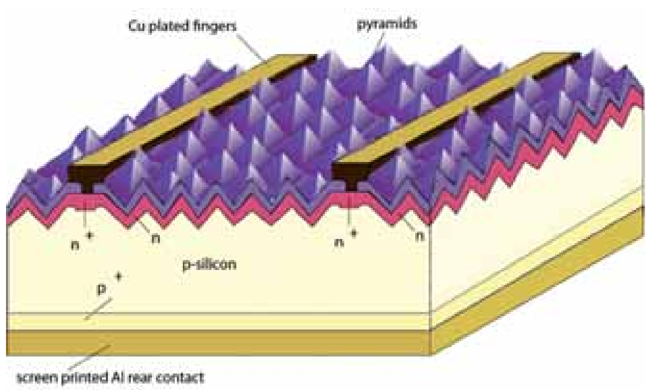
Using a patented laser process, researchers from the Photovoltaics Technology Transfer Team, working with solar technology firm Centrotherm, achieved a new world benchmark of 19.4% efficiency in May for a mass-produced, crystalline silicon solar cell. They improved that result in June to advance the record to 19.4%.

The previous record for cells created with this process was 18.9%. The new cells compare favourably with the 18%-efficient cells commonly used in rooftop solar panels.

Dr Matt Edwards, program manager in the UNSW School of Photovoltaic and Renewable Energy Engineering, said the records were achieved without exotic materials or equipment. "The exciting aspect of these records is that we achieved these results in a short time, using an industry-standard silicon wafer and modified industry-standard equipment. It's another step closer to solar power costing the same as coal-fired electricity."

Edwards said the gains, achieved on a standard p-type CZ silicon wafer, had produced a low-cost cell which delivered "the best bang for your buck" of any mass-produced cell in the world. The record-breaking cells were produced using the UNSW-patented laser doped selective emitter (LDSE) process, which uses a high-powered laser and a light-induced plating process to create ultra-fine metal contacts on the cell surface, leaving more area exposed to light to create more power.

Dr Matt Edwards with a record-breaking 19.4% efficient LDSE cell.



Schematic of the laser doped selective emitter (LDSE) cell.

One of the advantages of LDSE technology is its ability to boost cell efficiency with simple modifications to existing screen-printed solar cell production lines – the most common mass-production systems in use today. The process is already in pilot production at some facilities.

The UNSW group is now working on a new technology, double-sided LDSE (D-LDSE), which optimises both the front and rear surfaces of a solar cell to deliver efficiencies of up to 22%.

The new 19.4% efficiency record has been verified by the Fraunhofer ISE Solar Cell Calibration Laboratory and a paper detailing the work will be published in the inaugural edition of the *Journal of Photovoltaics*.

Excellence in Research:

Measuring the Performance of Physics

Frank P. Larkins

Research outputs in physics were presented by 24 of Australia's 39 universities for evaluation in the 2010 ERA exercise. Overall 20 of these universities and six of seven physics sub-disciplines were assessed to be at or above world standard. The leading group of Australian universities with both physics diversity and excellence are the Australian National University, Melbourne, Queensland, Sydney, Adelaide and Macquarie.

The Australian Government conducted the first Excellence in Research for Australia (ERA) exercise in 2010 through the Australian Research Council (ARC) [1] at an estimated cost of at least $100 million. The two- and four-digit Fields of Research (FOR) codes [2] were used to collect data from all institutions. There were 22 two-digit fields and 156 four-digit fields used with results also aggregated into eight multidisciplinary cluster categories. The assessments were made for more than 2400 units of evaluation (UoE) from all 39 universities using a quality rating scale of from 1 (well-below world standard) to 5 (well-above world standard).

One of the two-digit FORs was designated *02 Physical Sciences* with seven four-digit sub-discipline fields. These designations are the official Australian and New Zealand standard research classifications [2], but for the research profiled in this article the designation *Physics* will mainly be used in the text since the four-digit codes do represent physics sub-disciplines.

The outcome performances cannot always be directly aligned with Physics Departments since universities submitted works relevant to the field that could have been drawn from several departments. Furthermore, some sub-disciplines in which physicists undertake research, such as mathematical physics, are allocated to other FORs. However, this research leakage is minor since 92% of physics outputs were not shared with any other FOR. An analysis of the various fields does provide a valuable insight into the performance of Australian researchers as benchmarked against a world standard. The principal findings for the physics fields are discussed in this article.

Input data for the evaluation included total number of full-time equivalent (FTE) staff, research publication details, research grant and commercialisation incomes, patents, esteem measures and patents sealed. Citation information was sourced from the Scopus database – full details are available via the ARC website [1]. The census date for staff eligibility was 31 March 2009. Research publications were for a six-year period (2003–08), citations for 7.2 years (1 January 2003 to 1 March 2010) and the other inputs for three years (2006–08).

Physics in profile

Of a possible 39 Australian universities 24 (62%) submitted research work for evaluation in the physics field. The main core input data in aggregate on which the assessments were made are summarised in Table 1.

There were 65 physics UoE submissions at the four-digit level with 86% being assessed at or above world standard with an average four-digit national rating of 3.8 (see Table 2, column 10). The physics fields accounted for around 4% of national research output and 4% of Australian Competitive Grants. The most active fields in terms of number of submissions, income

Table 1. Some aggregate research data for the Physics 2010 ERA assessment

FOR code	FOR name	UoE assessed	Res. publns	Res. income ($ mill)	Commercial income ($ mill)	FTE staff	Esteem measure	Patents sealed
0201	ASS	13	3374	30.10	0.001	204	31	0
0202	AMNPPP	11	2746	28.42	0.058	152	29	0
0203	CP	1	441	3.94	0	33	6	3.8
0204	CMP	15	2425	44.05	1.584	196	37	6.8
0205	OP	12	3067	45.64	5.217	189	45	13.9
0206	QP	8	837	26.01	0.079	62	24	2.0
0299	OPS	5	779	25.19	0.302	130	19	2.2
Total	**PS**	**65**	**13,666**	**203.35**	**7.241**	**965**	**192**	**31.0**

FOR names: PS Physical Sciences; ASS Astronomical and Space Sciences; AMNPPP Atomic, Molecular, Nuclear, Particle and Plasma Physics; CP Classical Physics; CMP Condensed Matter Physics; OP Optical Physics; QP Quantum Physics; OPS Other Physical Sciences

and publications are Astronomical and Space Sciences (ASS), Atomic, Molecular, Nuclear, Particle and Plasma Physics (AMNPPP), Condensed Matter Physics (CMP) and Optical Physics (OP).

The ANU was the only university to submit work in the Classical Physics category. Research commercialisation income was low at 3.4% of the research income with the majority being derived from optical physics activities. OP also has the best patent record and the most academy members and fellowship holders. On a per-FTE staff basis AMNPPP has the best publication record and Quantum Physics (QP) the best research income record.

The overall performance ratings for physics (code 02) and the seven sub-disciplines are presented in Fig. 1. All the sub-disciplines were rated at or above world average (≥3) with the exception of AMNPPP (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. Quantum Physics (code 0206) is the most highly rated sub-discipline for multiple universities submissions, but Classical Physics (code 0203) with only ANU evaluated is the sub-discipline that is well above world standard. Overall, physics had an above world average two-digit rating of 3.7 rating out of a possible 5 (see Fig. 1, column 1).

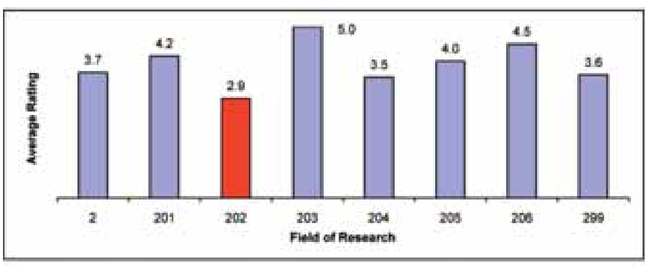


Fig. 1. ERA fields of research average ratings for physics and associated sub-disciplines.

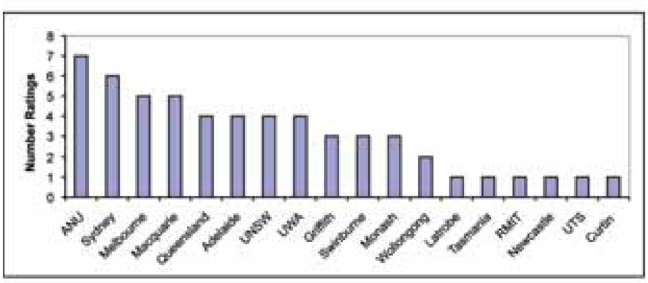


Fig. 2. Universities ranked according to the number of physics sub-disciplines rated at or above world standard (ie. ≥3).

Individual university performances

The 65 UoE ratings for the 24 universities that submitted research output data for assessment are presented in Table 2. The universities are listed in terms of the *maximum to minimum number* of four-digit fields for which they submitted data. This mode of presentation provides an insight into the *diversity* of sub-discipline activities within institutions, but not necessarily the *quality* of their performance.

The ANU was the only university to submit to all seven sub-discipline fields. Only nine of the 24 universities submitted in at least four of the seven fields. These universities were the Group of Eight and Macquarie. Five universities were assessed only at the two-digit level, because of low volumes of research outputs at the four-digit level. Based on these statistics, Australia has a rather narrow physics profile, recognising that there are 39 universities in the country.

The Physical Sciences committee determined that 20 of the 24 universities were at or above world standard at the two-digit level with an average rating of 3.67 and 15 of 19 universities on average at or above world standard at the four-digit level with the average rating being 3.78 (Table 2, columns 2 and 10).

Table 2. University ratings for two- and four-digit Physics Fields of Research

University	02	0201	0202	0203	0204	0205	0206	0299	Av. rating
ANU	5	5	3	5	4	5	5	4	4.43
Sydney	5	4	4		4	5	5	3	4.17
UWA	3	4	2		2	4	3	3	3.00
Melbourne	5	5	4		5	5	5		4.80
Macquarie	5	4	3		4	4	5		4.00
Monash	4	5	2		2	3		4	3.20
Queensland	5	5			4	4	5		4.50
Adelaide	5	5	4			5	3		4.25
UNSW	4	4	3		4	3			3.50
Swinburne	5	5	3			4			4.00
Griffith	5				4	3	5		4.00
Curtin	2	2	2		3				2.33
Wollongong	3				4			4	4.00
UTSydney	3				2	3			2.50
Newcastle	3	2			3				2.50
Latrobe	3				5				5.00
Tasmania	4	4							4.00
RMIT	3				3				3.00
Flinders	2		2						2.00
QUTech	4								
West Sydney	3								
South Qld	3								
James Cook	2								
Ch. Darwin	2								
Total entries	**24**	**13**	**11**	**1**	**15**	**12**	**8**	**5**	
Av. rating	**3.67**	**4.15**	**2.91**	**5.00**	**3.53**	**4.00**	**4.50**	**3.60**	**3.78**
Number ≥3	**83%**	**85%**	**64%**	**100%**	**80%**	**100%**	**100%**	**100%**	**79%**

FOR names: 02 Physics; 0201 Astronomical and Space Sciences; 0202 Atomic, Molecular, Nuclear, Particle and Plasma Physics; 0203 Classical Physics; 0204 Condensed Matter Physics; 0205 Optical Physics; 0206 Quantum Physics; 0299 Other Physical Sciences

This represents a remarkably good quality performance by Australian universities. It is a result that requires further validation. To more fully evaluate the assessments made, more understanding of the reference benchmarks for a performance *'at world standard'* is required.

Data for such an evaluation are not publicly available. Furthermore, the relationship between the two-digit and the four-digit ratings is not always clear from the data presented by the ARC. Of the 65 UoE university assessments 19 (29%) were rated 5, 22 (34%) were rated 4, 15 (23%) were rated 3 and 9 (14%) were rated 2, such that 63% of UoE were above world average. Universities with sub-disciplines rated at or above world standard are presented in Fig. 2 in order of the number of world standard entries.

Some 18 universities have at least one physics four-digit sub-discipline that is rated at or above world standard (ie. ≥3). ANU has the greatest depth in excellence followed by Sydney, Melbourne and Macquarie. When one considers only the well-above world standard category (ie. rating 5), ANU and Melbourne achieve this performance level in four sub-disciplines, followed by Adelaide, Sydney and Queensland in two fields. If one considers only the two-digit ratings (Table 2, column 2) then 20 universities are rated at or above a world standard performance with eight universities now having a 5 rating. On the basis of the combination of the two-digit and the average four-digit rating (Table 2, columns 2 and 10), the leading group of Australian universities with both physics diversity and excellence are ANU, Melbourne, Queensland, Sydney, Adelaide and Macquarie. All the fields in which Melbourne and Queensland were active were assessed to be above world average (ie. ≥4).

The Physical, Chemical and Earth Sciences cluster

The 22 two-digit FORs were grouped by the ARC into eight multidisciplinary clusters for evaluation purposes. Physical Sciences (02) was grouped with Chemical Sciences (03) and Earth Sciences (04) into the Physical, Chemical and Earth Sciences (PCE) cluster. Some comparative data for this cluster are presented in Table 3.

The PS field performance ranks well in comparison with the two other fields. PS research has fewer staff numbers in universities and less grant income than Chemical Sciences, but it has a higher research output and a higher overall rating with a similar number of at or above world standard UoE. The Earth Sciences community is smaller with research activities at fewer universities, but the standard of performance is extremely high. The PCE cluster is the best performed of all the eight clusters assessed by the ARC with an average performance rating of 3.7 and 92% of UoE being rated at ≥3. The average performance rating across all eight clusters is 2.8, with 59% of all two-digit UoE rated at 3 or above.

Future impact of the ERA

The ERA has been described by Minister Kim Carr as 'a key element of the Government's agenda for the

Table 3. Some comparative ERA data for the Physical, Chemical and Earth Sciences

FOR code	FOR name	4-digit UoE assessed	Av. rating 4 digits	UoE ≥3	FTE staff	Res. publns	Res. grant income ($ mill)	Esteem measure	Patent sealed
02	Physical Sciences	65	3.8	86%	965	13,666	$203.30	192	31.0
03	Chemical Sciences	86	3.5	86%	1154	11,915	$277.06	171	86.8
04	Earth Sciences	57	3.9	98%	718	8,258	$192.59	130	0.8
Total	PCE cluster	208	3.7	92%	2837	33,839	$673.00	493	118.6

reform of Australia's higher education system' [1]. It is planned for the ERA outcomes to become important in the Government compact negotiations with universities and in the allocation of funding for the indirect costs of research through the Sustainable Research Excellence program. It is not clear at this time how actual funding allocations will be made based on ERA outcomes, but eventually the evaluations could influence several hundred million dollars of funding.

More discussion and transparency is required on the world standards that are being established and on the decision-making processes being adopted to ensure confidence in the funding allocation mechanisms. The outcomes will be also used by government in other ways such as the development of a Research Workforce Strategy and other initiatives. It is also of considerable interest to the higher education sector as to how individual universities will respond to the external assessments that have been made. Will we see fewer universities involved in physics research in the future? Undoubtedly, the ERA outcomes will influence the setting of research priorities for future investments in many universities. It will be several years before the full reforming impact of the ERA exercise will be realised.

It has been announced that there will be a further assessment round in 2012 with the census date for eligible researchers being 31 March 2011. The journal ranked list [3] was a key factor in the assessment of the quality of the research outputs submitted for the 2010 round. A further announcement is that a number of changes will occur for the 2012 exercise [4]; in particular, the 2010 prescriptive journal and conference quality indicators will be replaced by a more flexible approach giving more discretion to the evaluating committees.

While a further trial of refinements to the ERA methodology may be justified for 2012, given that the total cost of each exercise is at least $100 million, it is doubtful whether sufficient new information can be obtained to warrant repeating the evaluation exercise thereafter more frequently than every five years. Universities have a right to expect increased transparency on how the information will be used in decision-making funding allocations as processes are refined.

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BIO

Frank Larkins is Professor Emeritus in the School of Chemistry at the University of Melbourne and a former Deputy Vice Chancellor, Dean of Science and Dean of Land and Food Resources at that university. He is a graduate of Melbourne and Oxford Universities. He has held appointments at Battelle Institute, USA, and at the universities of Oxford, Monash, Tasmania, Oregon and Melbourne. He is a fellow of the Australian Physics, Chemistry and Energy Institutes and of the Australian Academy of Science and the Australian Academy of Technological Sciences and Engineering. He has published more than 200 scientific papers. His current interests are in research, education and energy policy developments. He has recently published a book entitled 'Australian Higher Education Research Policies and Performance 1987–2010' (Melbourne University Press, 2011). He also has roles as Chief Scientist, Energy at the Victorian Department of Primary Industries, as Director of the Melbourne Business School, as Chair of the University of Melbourne International House Council and as a principal advisor to the Vice Chancellor at the University of the South Pacific.

[Credit: Emil Lenc, Australia Telescope National Facility]

Searching for the Highest Energy Particles in Nature

Clancy James

Cosmic rays are relativistic protons and atomic nuclei bombarding the Earth from outside the Solar System. The rarest and most energetic cosmic rays – the so-called 'ultra-high energy' or UHE cosmic rays – contain more than a Joule of energy in a single particle. Two broad classes of models for how nature produces such extreme particles have been proposed: 'bottom-up' models, involving low-energy particles being accelerated by the relativistic collision of plasmas, and 'top-down' models whereby some as-yet unobserved particle – for instance, super-heavy dark matter – decays into cosmic rays. But, despite over fifty years of study, the source of these extreme particles remains unknown.

Why not? Firstly, UHE cosmic rays are rare, being seen about once per square kilometre per century. Secondly, they are deflected by cosmic magnetic fields, and their observed arrival directions may not relate to their source. The largest existing detector – the Pierre Auger project in Argentina – already covers 3000 km^2 [1], and a bigger detector is needed to gather enough cosmic-ray events to determine their origin.

'Bigger' may not necessarily mean 'more expensive' however, and the key to the mystery may not lie in cosmic rays at all. As UHE cosmic rays travel through the universe, they will interact with background photon fields to produce, among other things, neutrinos [2, 3] (see Fig. 1). Unlike cosmic rays, neutrinos are uncharged and they are unaffected by magnetic fields, so their arrival directions will point the way back to their source. Additionally, their all-sky flux would indicate the class (top-down and bottom-up) of cosmic-ray production. The problem is that nobody has observed these UHE neutrinos as yet.

The 'garden-variety' neutrinos with which we are more familiar are those produced during fusion reactions in the Sun's core, which due to their relatively low energy, mostly pass through the Sun and Earth unhindered. At ultra-high energies, the interaction probability increases, but any type of neutrino – ν_e, ν_μ or ν_τ – will still penetrate of order 100 km of material before interacting. To detect them therefore, similar to cosmic-rays, a huge detector is needed.

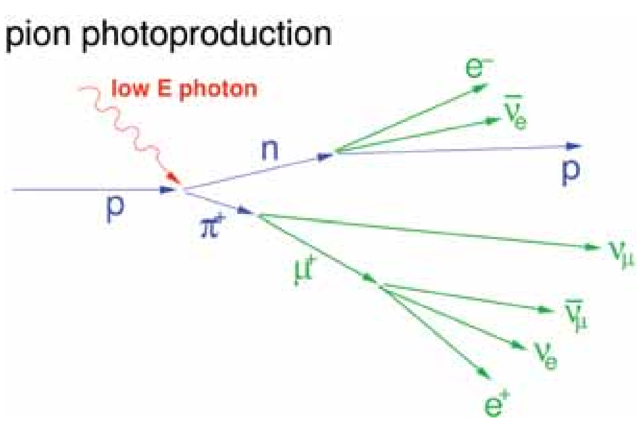

Fig. 1. A typical GZK interaction: an ultra-high energy cosmic-ray proton *p* collides with a low-energy photon – many of the interaction products eventually decay into, among other things, neutrinos. [Courtesy: R. Protheroe]

Detection method

Luckily, there is a solution. As predicted by Askaryan in the early 1960s [4] and confirmed by the Stanford Linear Accelerator Center [5], when a high-energy particle interacts in normal matter, it produces a cascade of secondary particles which give off a short, intense burst of radio waves with a duration of as little as a few nanoseconds. The energy radiated due to the 'Askaryan effect' scales with the square of the primary particle's energy. Thus any pulse from an UHE particle – neutrino or cosmic-ray – should be very strong indeed, allowing them to be observed from very large distances. Perhaps, as proposed by Dagkesamanskii and Zheleznykh [6], even as far away as the Moon.

Askaryan had already suggested placing a detector on the Moon, since the outer layers were sufficiently transparent to radio waves that pulses generated at shallow depths could reach the surface. Dagkesamanskii and Zheleznykh however reasoned that the Moon should be observed with Earth-based radio telescopes to utilise the entire visible surface of the Moon (about 10,000,000 km^2) as a neutrino and cosmic-ray detector. While the distance of the Moon to the Earth meant that only the most energetic particles could be detected in this manner, this was an effectively free detection area/volume which simply could not be matched on Earth. Another advantage was that conventional radio telescopes had already been observing the Moon for years – they just hadn't been looking for the right signals.

The methodology behind the Askaryan, Dagkesamanskii and Zheleznykh (ADZ) technique is thus: take a radio telescope, point it at the Moon and look for nanosecond pulses of radio waves. If you see a pulse that could not have been caused by random thermal noise fluctuations or radio-frequency interference (RFI) – hey presto! You have a UHE particle detection.

The Square Kilometre Array and LUNASKA

When I began my PhD work at the beginning of 2006, three previous experiments had attempted the ADZ technique, and none had successfully identified a UHE particle. The challenge of hunting for UHE particles with conventional radio telescopes is that they are not designed to search for pulses which last of order only a few nanoseconds. As revealed by the first ADZ experiment by Hankins *et al.* [7] with the Parkes telescope, many man-made devices – cars, air-conditioners, and electric fences to name but a few – produce RFI which mimics a lunar pulse. Additionally, even pulses from the highest-energy particles will be very weak by the time they travel from the Moon to the

Earth. To overcome these problems, an increase in both raw detector sensitivity and sophistication is required, and the SKA promises both in ample amounts.

The Square Kilometre Array (SKA) is a radio telescope planned to be built in Southern Africa or Australia–New Zealand between 2016 and 2023 (the announcement of the chosen site is expected in 2012). Named because the total collecting area will be approximately 1 km^2, it will consist of thousands of individual antennas spread over hundreds of kilometres. Its sensitivity will be ten times that of the next-most-sensitive radio telescope at Arecibo in Puerto Rico, and it will have a wide frequency coverage ideal for searching for broad-band pulses. Additionally, both proposed sites have been officially designated as radio-quiet zones by the governments involved – no more troublesome RFI! It promises to be a near-ideal instrument with which to search for pulses from UHE particle interactions.

Using the SKA for UHE particle detection was the idea behind the formation of the LUNASKA (lunar ultra-high-energy neutrino astrophysics with the SKA) collaboration, led by Ray Protheroe at the University of Adelaide and Ron Ekers at ATNF/CSIRO. However, to harness an instrument such as the SKA for nanosecond-scale astronomy, many unsolved questions need to be answered. How does the pulse strength vary as a function of frequency? What is the optimal detection strategy? Just how sensitive will the final SKA be to lunar pulses? Thus the goal of LUNASKA is to develop methods and techniques for using instruments such as the SKA to search for lunar neutrino and cosmic-ray pulses. The test-bed for the project is the Australia Telescope Compact Array (ATCA), an array of six 22 m-diameter radio telescopes on a 6 km east–west baseline located near Narrabri, NSW (see banner image).

Fig. 2. An optical image of Centaurus A with an overlay radio emission (pink). The main galaxy is in the centre. The radio emission comes from jets of material shot out by the central black hole of Centaurus A. This emission could be a signature of the production of UHE cosmic rays. [Courtesy: the Capella Observatory; and Ilana Feain, Tim Cornwell, Ron Ekers (CSIRO/ATNF), R. Morganti (ASTRON) and N. Junkes (MPIfR)]

Simulating the ADZ technique

The story described above was as it stood at the beginning of my PhD thesis in 2006. The goal of the LUNASKA project is to primarily observe neutrinos, for which the LUNASKA project had received funding from the ARC. My PhD project was to work on the theoretical aspects of the technique – I was still a little scared of getting my hands dirty with real experiments, and fancied myself a theorist. Based at the University of Adelaide, and supervised primarily by Ray Protheroe (co-supervised by Ron Ekers), the first goal of my PhD was to develop a Monte Carlo simulation of the detection method, to determine the sensitivity and op-

Fig. 3. The LUNASKA data-acquisition equipment inside one of the ATCA antennas. The main electronics are contained in the gold-coloured box at lower-centre. The spiral-shaped devices at top-left were built to reverse the dispersion (frequency-smearing effects) of the ionosphere.

timal set-up of planned experiments with the ATCA and eventually the SKA.

To briefly outline the physics incorporated into the simulation: the program modelled high-energy neutrino cross sections for various interaction modes; the structure of the Moon, from its density profile to the surface roughness; the properties of the cascades of secondary particles resulting from primary-particle interactions, and the radiation they produce; properties of the regolith, such as its radio-absorptivity and depth; and the response of a radio telescope to incident signals, including the random noise component and different sensitivities to different parts of the Moon. After approximately a year's worth of programming, the simulation was finished. The output? Simply the probability of detecting a given neutrino or cosmic ray incident on the Moon as a function of the particle's energy and arrival direction.

The first test of this new program was to see if it could reproduce established results. For the Lunar ADZ technique, that meant re-calculating the sensitivity of the Goldstone Ultra-high-energy Neutrino Experiment (or GLUE) [8]. Yet for all my hard work, the simulation estimated a detection probability for that experiment about ten times less than the published results. Naturally I assumed the problem was with my code, but after approximately two months' worth of checking and debugging this could still not be explained.

The cause was revealed when I compared my simulation results to those from a Russian experiment at Kalyazin [9] – my estimates agreed perfectly! This cast a two–one vote against the GLUE results (since then Gayley *et al.* [10] have explicitly confirmed my sensitivity estimates). Therefore, the first conclusion of my PhD research was: Lunar ADZ experiments were a factor ten less sensitive than we thought they'd be – a depressing result, but the correct one.

Experiments at the Australia Telescope Compact Array

While the ADZ method was not as sensitive as first thought, the simulation program still predicted that the SKA would be an amazing instrument to study these elusive particles. Therefore, the LUNASKA group began to plan for a series of observations using the Australia Telescope Compact Array (ACTA). My role in these observations was to determine the best obser-

vation dates, be an all-round problem-solver, and analyse the resulting data.

Given the reduced sensitivity estimates for our planned experiments, we knew that just pointing the telescope blindly at the Moon would be unlikely to detect any neutrino signals. However, my simulation had also shown that the sensitivity of this experiment would not be uniform over the whole sky. Since a UHE neutrino cannot penetrate through the entire Moon, only particles 'skimming' the edge of the Moon would be observable. While this favoured particles coming from directly behind the Moon, the emitted radiation from these skimming events would be greatly weakened by being refracted at close to a 90° transmission angle, favouring particles coming from angles far from the Moon.

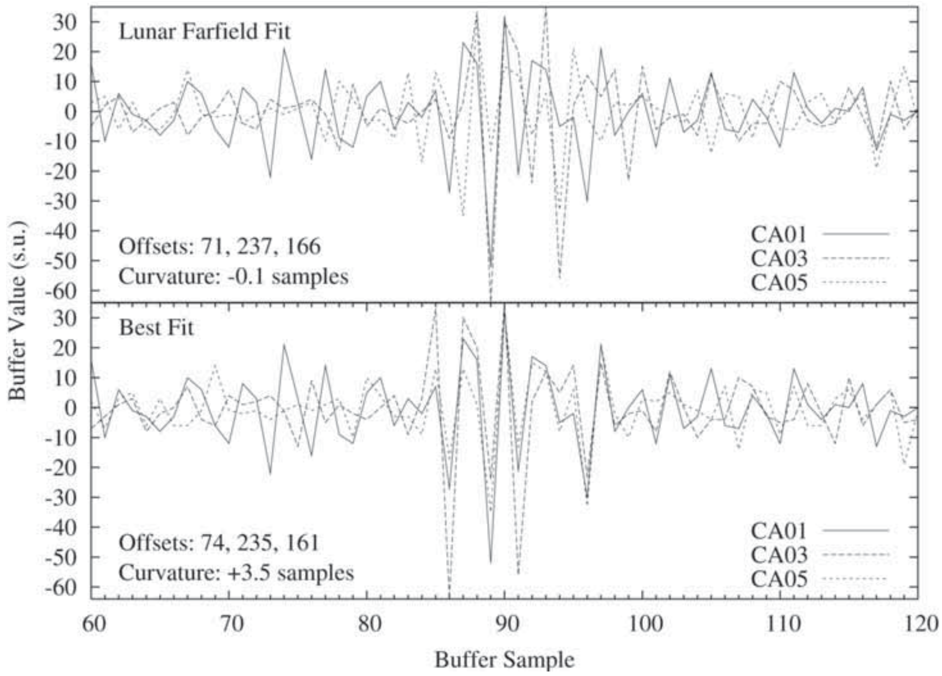

Fig. 4. The most likely neutrino candidate event. Shown are recorded voltages (arbitrary units) as a function of 'buffer sample number' (approximately 5×10^{-10} seconds per sample). The top panel shows the best fit achieved by forcing the signal to come from the Moon, while the bottom panel shows the best fit by allowing the arrival direction, and distance, to vary. Clearly, the event did not come from the Moon.

Combined, these effects made for a 'sweet spot' of sensitivity about 20° away from the Moon, so that a suspected source of UHE particles could be targeted by focussing a radio telescope on that part of the Moon closest to the suspect source. And as it turned out, previous experiments – with on average higher sensitivity – had not been sensitive to the most likely candidate source of UHE particles: the active galaxy Centaurus A (see Fig. 2).

LUNASKA applied for and received time on the ATCA both in February and May 2008, after some initial testing in 2007. The observations required searching for short-duration pulses in each of three of the ATCA antennas, after correcting for the dispersion in the Earth's ionosphere, which also meant we had to observe at night. The hardware which detected the pulses and the software which recorded and analysed the signals had to be purpose-built (see Fig. 3). Indeed, this experiment was only possible because of the work of Paul Roberts and Chris Phillips who, respectively, built the hardware and wrote the software.

The observations themselves involved a lot more than simply pointing the antennas at the Moon and waiting for a neutrino to arrive. Since nobody had observed at the Compact Array at such high time-resolution, we observed a whole host of unidentified pulsed signals, and we initially had little idea if they were real events or a hardware failure. Mostly, they were real – to our consternation, the most troublesome piece of RFI we saw was actually generated by the antennas themselves, specifically the diode which gave us a calibrator to measure our system temperature and hence sensitivity. So numerous were RFI events that, at the end of six nights of observations, we had accumulated over 10 million of them. It was then my job to search through this data for the perhaps one or two signals which could have been caused by neutrinos interacting with the Moon.

A search for UHE particle pulses with the ATCA

The criterion used to distinguish real Lunar events from random RFI signals was the relative time of arrival of the signals between our three ATCA antennas: we knew that signals must come from the Moon, unlike radio-frequency interference which would mostly originate from the anthropogenic sources on the ground. The precision given by our equipment was amazing: Fig. 4 gives an example of our most likely candidate event, which regrettably could not have come from the Moon since the fitted source distance was approximately 100 km.

Using these techniques, all candidate events were excluded. This was not entirely unexpected – indeed, every experimentalist hunting UHE neutrinos is going to expect to find none until, finally, one experiment will in fact be successful. That is simply the nature of the game when you are searching for something about which so little is known, and we were not the lucky ones to make the breakthrough.

But there are a lot of positives to be gained from our experiment. Firstly, we could be 100% certain that we had not observed a neutrino candidate. This may not sound impressive, until you consider that for each event we had only one ten-millionth of a second's worth of data to work with. Thus we were able to publish strong limits on the flux of neutrinos coming from Centaurus A.

Secondly, and most importantly for the goals of LUNASKA, we had learnt a lot about how to search for pulsed lunar signals. Most relevant for the SKA is that the sensitivity of a Lunar ADZ experiment is limited not by the number of telescopes used in the search, but by the information which can be used in real-time triggering. Importantly, we also learnt that much or most of the short-duration RFI events are generated by on-site electronics. This means that when the SKA is eventually built in a pristine RFI-free environment, it will bring its RFI with it.

The future

The LUNASKA collaboration has now moved on to using the Parkes radio telescope for Lunar observations, since it provides a higher raw sensitivity than the ATCA, and we have learnt all our required lessons from the ATCA as a down-sized SKA-like instrument. I have since worked – amongst other things – on the 'NuMoon' project, which aims to perform similar observations at lower frequencies (100–200 MHz) with the Low Frequency Array (LOFAR), a new radio telescope centred in the Netherlands only now reaching completion. For all our efforts though, it may turn out that the predicted flux of UHE neutrinos will not be found. And that could be the most interesting result of all.

Acknowledgment

Clancy James would like to thank the Ferry foundation for their financial support during his PhD research, and the fellow members of LUNASKA – Jaime Alvarez-Muniz, Justin Bray, Rebecca McFadden, Chris Philips, John Reynolds, Paul Roberts, and especially his supervisors Ray Protheroe and Ron Ekers – for doing a great job on a fantastic project. If Nature had provided us with neutrinos to observe, we would have seen them.

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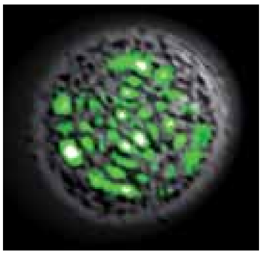
BIO

Clancy James grew up in Stirling, SA, and holds a B.Econ. (2004) and a B.Sc. (Hons) (2005) in physics, both from the University of Adelaide. In 2009 he was awarded a PhD by the University of Adelaide for his research on 'Ultra-high energy particle detection with the lunar Cherenkov technique', for which he also was awarded the 2010 AIP Bragg Gold Medal and the 2010 Postgraduate University Alumni Medal. After receiving a 2009 Rubicon Fellowship to work at Radboud University Nijmegen, The Netherlands, in July 2011 he moved to the ANTARES underwater neutrino detector at the Erlangen Centre for Astroparticle Physics, Germany.

Left: AIP President Brian James presents the 2010 Bragg Gold Medal to Clancy James for his thesis on ultra-high energy cosmic rays.

A living laser

To date, lasers have been built from inanimate materials, such as purified gases, synthetic dyes or semiconductors. But now physicists in the US have shown how to induce lasing in a single living biological cell. By shining intense blue light onto fluorescent protein molecules in a cell, the team made the molecules generate intense, monochromatic, directional green light. This phenomenon could potentially be used to distinguish cancerous cells from healthy cells, claim the researchers.



Living laser lights up life.

The material used in the latest work is the green fluorescent protein (GFP), which is found in the jellyfish *Aequorea victoria* and has been used to image live cells since the 1960s. By combining the gene that encodes GFP with the DNA of any other protein, the GFP can be attached to that protein. The light it gives off can then be used to track the protein in living cells.

The natural fluorescence of GFP is incoherent, but Malte Gather and Seok Hyun Yun, at the Massachusetts General Hospital and Harvard Medical School in Boston, thought it might be possible to amplify the protein's light and so build a biological laser. By optical pumping with nanojoule/nanosecond pulses, individual cells in a high-*Q* microcavity produce bright, directional and narrowband laser emission, with characteristic longitudinal and transverse modes. Lasing cells remained alive even after prolonged lasing action. Light amplification and lasing from and within biological systems pave the way to new forms of intracellular sensing, cytometry and imaging.

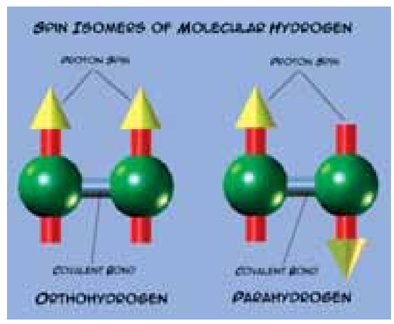
The work is published in *Nature Photonics* **5**, 406–10 (2011).

NMR spectroscopy without the 'M'

Nuclear magnetic resonance (NMR) spectroscopy is perhaps the most useful technique in the organic chemist's toolkit. But conventional NMR requires the sample to be placed in a very high magnetic field, which needs large and expensive superconducting magnets cooled by liquid helium. Now, an interdisciplinary group in the US has managed to accomplish NMR spectroscopy without magnets. The work could lead to portable NMR spectrometers, and possibly even small personalised spectrometers for medical diagnosis.

The signal intensity in conventional NMR increases roughly as the square of the magnetic field strength. NMR spectrometers over the years have therefore become bigger, more powerful and more expensive. The alternative – NMR spectroscopy with no applied field – seems bizarre because it should mean no energy gap, no spin polarisation and nothing to measure. Despite the use of superconducting quantum interference devices or atomic magnetometers, low-field NMR typically suffers from low sensitivity compared with conventional high-field NMR.

Here the authors, based at UC Berkeley, demonstrate direct detection of zero-field NMR signals generated through a technique known as parahydrogen-induced polarisation, enabling high-resolution NMR without the use of any magnets. The sensitivity is sufficient to observe spectra exhibiting ^{13}C–^{1}H scalar nuclear spin–spin couplings (known as *J* couplings) in compounds with ^{13}C in natural abundance, without the need for signal averaging. The resulting spectra show distinct features that aid chemical fingerprinting. While the phenomenon of parahydrogen-induced polarisation has been known for some years, the current work is the first to successfully use it in zero-field.



The two spin isomers of molecular hydrogen.

The research is published in *Nature Physics* **7**, 57–75 (2011).

Catching sight of the elusive wavefunction

In the orthodox interpretation of quantum mechanics, the wavefunction contains the maximal knowledge that is available about the state of a system. It determines the probabilities that various results will be obtained when measurements are made on the dynamic variables of the system such as its position or momentum.

However, measuring the wavefunction is no easy task. Thanks to Heisenberg's uncertainty principle, measuring a quantum system without effectively de-

stroying it before the wavefunction is fully known has seemed impossible. Now, by taking a new approach to quantum measurement, Jeff Lundeen and his team from the National Research Council, Canada, have directly measured the wavefunction of identical single photons for the first time.

The wavefunction of a photon, containing all the information about it at any given time, is colourfully depicted in this artist's interpretation, superimposed on an image of the experimental set-up used by Lundeen and his team.

Making a measurement on just one copy of a system – such as just a single photon – gives us part of the wavefunction. However, the measurement must be repeated many times on an ensemble of identical photons to gain enough information to construct the entire wavefunction. This indirect form of measurement is known as 'quantum tomography' and has been used for some time.

By contrast, Lundeen's team has worked out a way to directly probe both the real and imaginary parts of the wavefunction of an ensemble of photons. The method relies on the concept of 'weak measurement', which has been used recently to measure some quantum systems – and does not destroy the wavefunction.

The research is published in *Nature* **474**, 181–91 (2011) and is accompanied by a commentary article by Hosten [*Nature* **474**, 170–1 (2011)].

A critical point for turbulence

One of the great triumphs of early 20th-century science was determining the exact conditions for the occurrence of the transition between the dynamical states of smooth laminar flow and complex, turbulent flow for many types of flows. For most cases, a well-defined critical flow speed could be determined where laminar flow becomes susceptible to small perturbations and gives way to turbulence. One of Nature's whims is that the technologically important case of pressure-driven flow through a cylindrical pipe does not fit into this classification. Now, Avila *et al.* show how a critical point for turbulent pipe flow may finally be identified.

Avila *et al.* studied the flow of water at speeds of about 0.5 m/s in a pipe 4 mm in diameter and 15 m in length. All of these dimensional quantities can be combined into a single relevant dimensionless parameter, the Reynolds number $Re = UD/\nu$, formed by the mean velocity U, the diameter D of the pipe, and the kinematic viscosity ν of the fluid. A transition from laminar to turbulent flow is often observed near Re of about 2000, but the quoted values vary considerably, not only between publications or experimental facilities but also between runs at the same facility. So should this be construed as a transition without a critical point?

The researchers show that in pipes, turbulence that is transient at low Reynolds numbers becomes sustained at a distinct critical point. Through extensive experiments and computer simulations, they were able to identify and characterise the processes ultimately responsible for sustaining turbulence. In contrast to the classical view that turbulence arises from an increase in the temporal complexity of fluid motion, here, spatial proliferation of chaotic domains is the decisive process and intrinsic to the nature of fluid turbulence.

The findings of Avila *et al.*, and even more so their method of analysis, bring into focus the spatiotemporal aspects of the transition problem. They pave the way for a better understanding of the transition in pipe flows and related shear flows and connect the transition to the spatial intermittency and phase transitions in directed percolation. They provide not only the long-sought critical Reynolds number for pipe flow, but also define a critical change in our approach to studying turbulence transitions in spatially extended systems.

The research is published in *Science* **333**, 192–6 (2011). See also the *Science* Perspective article by Eckhardt [*Science* **333**, 165–6 (2011)].

How to make a superlens from a few drink cans

'Acoustic metamaterial' may sound exotic, but researchers in France have managed to assemble one from a few multipacks of cola cans. Arranged in a grid, the drinks cans act as a superlens for sound, focusing acoustic waves into much smaller regions than their metre-long wavelengths typically allow. The cans act as resonators, directing the volume of the sound to peak in a space just a few centimetres wide, and this heightened precision could improve acoustic-actuator systems.

Propagating light or sound waves diffract when they encounter an object, with the resulting interference preventing the waves from being focused to a spot smaller than about half their wavelength. However, the scattering process also involves evanescent waves, which prevent discontinuities in the electromagnetic field and fade away quickly – within half a wavelength of the reflecting object. Superlenses pick up and amplify these evanescent waves and offer a way of beating the diffraction limit. Now Geoffroy Lerosey and colleagues of the Institute Langevin in Paris have developed a system to build and control evanescent waves in order to tightly focus acoustic energy.

Physicists made this acoustic superlens from an array of 49 drinks cans. Also shown are the driving loudspeakers and the microphone suspended above the array.

Each can resonates at about 420 Hz. However, by assembling 49 cans into a seven-by-seven square, the cans resonate collectively rather than individually. By playing a single tone using different combinations of the eight speakers surrounding the array of cans, the researchers are able to make the cans resonate at frequencies of about 340–420 Hz. These resonances are the evanescent waves building up among the cans.

The different resonances produced different shapes in the pressure distribution across the array, measured with a microphone suspended above the cans. Once the researchers had recorded the 49 pressure distributions, or resonant modes, they were able to devise ways to layer the resonances so that these built up in some places and cancelled out in others.

This technique concentrates the acoustic waves on a spot one-quarter the size of the diffraction limit, but spot sizes much smaller than this can also be achieved. It is believed to be the first demonstration of super-resolution of sound in the far field. This research will be published in *Physical Review Letters*.

Carbon nanotubes could store solar energy

Alexie Kolpak and Jeffrey Grossman at MIT in Boston have designed a new solar thermal fuel that could store up to 10,000 times more energy than previous systems. The fuel, which has been studied using computational chemistry but not yet fully tested in the lab, consists of carbon nanotubes (CNTs) modified with azobenzene. It is expected to provide the same energy storage per volume as lithium-ion batteries and can store solar energy almost indefinitely. It can also be recharged by simply exposing it to sunlight – no electricity required.

Solar thermal fuels work by storing energy from the Sun in the chemical bonds of molecules. For example, a typical fuel molecule in, say, its ground state A absorbs light from the Sun. This light absorption transforms state A into state B. Here, only the geometry of the molecule changes and no chemical reaction occurs. Such molecules are said to be 'photo-switchable'. When a trigger – which can be in the form of heat, light or a voltage – is applied, a molecule in state B switches back to state A and the stored energy is released as heat. The heat could be used directly or to generate electricity. After the heat is released, the solar thermal fuel can easily be recharged by exposing it to sunlight.

Although many solar thermal fuels were developed in the 1970s and 1980s, they degraded rather quickly with each cycle. Currently, there is only one solar thermal fuel that can cycle many times without degradation, in addition to the new one created by Kolpak and Grossman, but it is based on ruthenium, which is rare and expensive. What is more, the volumetric energy density of this fuel is very low in contrast to that of azobenzene/CNT.

The researchers admit that there are still many challenges to overcome before they can even consider commercialising such a technology. The work will be published in *Nano Letters*.

Experiences from an Adventure in Kenya

Mathew Creese

I first visited the Mwea Children's Home, Kenya, in November 2008, after I was put in contact with them by a family friend. The home is situated in a rural area approximately three hours north of Nairobi and is run by the Bethlehem Community Centre Africa (BCCA) for children, aged 4 to 18, who are orphaned and destitute as a result of poverty, HIV/AIDS, tribal conflicts, to name a few.

The day after my final undergraduate exam at the University of Tasmania I stepped onto the plane bound for Africa wondering what the next month of volunteer work would entail. I needn't have worried – I received the warmest of welcomes and enjoyed it so much that I promised my 75 new best friends that I would return as soon as I had completed the next stage of my studies.

And so it was, that on a lazy Sunday afternoon a little over a year later, I found myself watching one of the youngest orphans playing with a magnet. I managed to find a needle in my medical kit and after a few strokes against the magnet, I had made the first compass that many of the kids had ever seen. With a little trickery I was soon deviating the needle with the magnet hidden in my hand.

A look of pure amazement came across the children's faces, as they stood around me staring mystified at the floating needle – magically moving as I passed the back of my hand close by. Many reached out and tried with theirs. "Is it his white skin?" they asked one another, but it wasn't long before they discovered the source of my magic.

With all the children back in school, some days could be quite long at the orphanage. The home's manager suggested that, as I had just finished uni, I could help teach a few days a week at the local high school when not otherwise busy. So, I met with the principal and resident physics/maths teacher of Ndindiruku Secondary School to discuss possible options – and it wasn't long before David, the physics teacher, started to plan as many classes as he could for me!

Word spread quickly and there was quite a buzz amongst the students, many peering around the corner to catch a glimpse of the mazungu (white man). The principal had a chuckle and said that everyone would be very excited at the prospect of me teaching.

The Kenyan education system consists of eight years of primary school, Standard 1 to 8, with attendance mandatory and no tuition fees. Students sit a national standardised exam at the end of Standard 8, with the results determining what type of secondary school they can enter.

Secondary education is four years, Forms 1 to 8, where tuition is no longer subsidised. The most prestigious are the national schools, which admit only the top ranking students. The next rung down are the provincial schools and below these are the district schools, with the lowest ranking students and those who cannot afford better. Ndindiruku Secondary School is one of these.

Something I found intriguing was that, although the national language of Kenya is Kiswahili, the official language is English. Generally, at home children first

Ndindiruku Secondary School. There are four classrooms for Forms 1 to 4 starting from the left, and then the laboratory to the right of the main building. The building at far right is for the principal, secretary, deputy principal and eight teachers.

learn their mother tongue – Kenya has some 69 recognised individual languages – as well as Swahili. English is then taught at primary school, but once children reach secondary school, all classes are taught in English.

After experiencing the Australian education system, it came as quite a shock to tour a typical village secondary school that consisted of only four small classrooms and a 'laboratory', if it could be called as such, to cater for around 300 students. The laboratory was nothing more than a few wooden benches with holes where the sinks should be. There was no running water and electricity is a luxury that is well beyond reach.

With the final exams consisting of 60% theory and 40% explanation of practicals, it is no wonder few students choose science subjects, and those who do often fail. The physics teacher David explained that taking lab sessions is extremely difficult due to the lack of resources. However, a box had just arrived with some supplies which almost doubled the school's equipment. After an eye-opening first visit, I walked back to the children's home with the Form 2 & 3 physics and maths textbooks under my arm to read over night.

With Form 3 physics studying the properties of light and three glass prisms having just arrived, I had an idea during the first day and thought I would test my MacGyver skills. When I returned to the home, out came my head torch, the cardboard box from my soap, my diaries' front plastic cover and a pocket knife. I was quite pleased with the result: a functioning single slit ray box, held together with medical tape!

The next morning I awoke with the kids at 6 am, made a small fire to heat bathing water, threw a few handfuls of the slightly smoky water over myself and tried to resemble a respectable Kenyan teacher. I enjoyed the daily mug of Uji (porridge made from maize, millet & sorghum meal) and was out the gate by 7:40.

After a little pre-class tweaking, I showed the students the splitting of white light through a triangular prism in the bottom of a bucket, followed by an explanation using the relevant theory and equations on the blackboard. As expected, the eight students were very shy at the beginning but were more comfortable by the end. David sat in on the lesson, said it was excellent and that I could come back tomorrow!

Most days walking through the village to and from school were very entertaining. Typically by the time I reached the opposite side of the village, there would be at least a dozen young children following me. The first couple of times, when I turned around to have a look they would do either one of two things: Run, or try and hide behind each other!

"A look of pure amazement came across the children's faces, as they stood around me staring mystified at the floating needle – magically moving..."

For most of these young ones, I was the first white person they had seen. I stopped, squatted down and tried to greet them. The first adventurous ones carefully came up and touched my hand before returning quickly to the anxious crowd. Once they realised I was friendly, I soon had small kids running across the field to shake my hand. Another common occurrence was mothers offering their daughters. "Look. She very beautiful, isn't she? You take her back and make your wife!"

For the next week I took the Form 3 physics class, to the delight of both students and teacher. As well as just theory, we managed to do a couple of pracs. One

The school laboratory showing some students carrying out an 'apparent versus true depth' experiment.

with rectangular prisms and my handy ray box to show the refraction of light. Another was on the apparent versus real depth of a pin in a beaker of water, and using this to calculate the refractive index from air to water.

"My time spent at the children's home and teaching in the school has helped me to realise the importance of education. It is clearly a vital link in breaking the cycle of poverty…"

Soon, I was taking more than just physics. The Form 4 maths class were given to me for trigonometry. After the first day's lesson they asked me a few questions, apparently with the aim of figuring out my age. When told that I was 23, some were shocked, whilst others were almost hysterical. Most of the students were the same age as me and a couple were a year older. Some of the boys jokingly asked if I was married. "No, I am single". More hysteria…

During a morning lesson on a Friday of the first week of trig, the students asked if I could take them for an extra lesson in their free time after lunch. A little after the morning break, some of the students told me their English teacher was setting the upcoming exam, so I could take them now till lunch. We reached lunch and I asked them if they still wanted the afternoon lesson, they replied, "Yes, still OK Teacher Mathew".

At the end of a full day of trig, I set some homework for the weekend. I could feel the students making progress, all they needed to do was practice. "What about tomorrow?", they asked. I replied it would be Saturday. "We come and do extra work if we can get a teacher." After a little negotiation, I agreed to meet any students interested for a couple of hours.

The torrential rain sounded like hammers on the tin roof above my wire bed that night. The next morning, as I negotiated some very muddy paths through the village, I wondered if anybody would turn up. Sure enough, only one girl was there waiting. We started, but over the next hour around a dozen students came one by one. For the next four hours we solved practice examples using the newly learned SOH CAH TOA (I may be the first to have introduced this acronym into rural Kenya), covered questions from chemistry, English and even a couple on agriculture.

During lunch I would sit amongst the teachers, whilst we enjoyed the staple of boiled beans and maize prepared each day. After a while we started to discuss the hindrance of not being able to afford electricity, let

Most of the Form 4 class enjoying a soda on the last day of term.

alone computers. To my amazement, I found that it was now mandatory for the final year students to be registered for the national exams online. After discovering I had my laptop with me they asked if I could type up a couple of exams. Previously they would handwrite the exams, give them to the secretary to produce a negative on a tired old typewriter, who would then copy them using a hand copier. The end result was usually a messy and sometimes illegible exam paper.

The next day I took 15 copies of the Form 3 chemistry exam to school, which I produced on the printer I had bought for the home. The chemistry teacher showed the other teachers, who were all very impressed with how neat and detailed they were. Over the next few days – much to the delight and relief of the school secretary – I typed up and printed out the remaining chemistry, maths and physics exams!

All too soon it was the end of term and I had to say goodbye. As a send-off some of the students pooled their money and bought a crate of soda, which we all thoroughly enjoyed. The last question everyone asked was "When are you coming back Teacher Mathew?" It is a question that I still ponder regularly.

My time spent at the children's home and teaching in the school has helped me to realise the importance of education. It is clearly a vital link in breaking the cycle of poverty that these Kenyan children are caught in. The kids at the home knew this, as did many of the students with their voracious appetite for knowledge. Each evening in the home, I would join with the children as they spent at least an hour studying under a single gas lamp. It is a terrible injustice and a source of great sadness to me that so few will ever be able to afford the resources to allow them to escape this cycle.

BIO

Mathew Creese completed a B.Sc. in physics at U. Tasmania in 2008 and was awarded the AIP physics prize. At the end of 2008 he made his first trip to the Bethlehem Mwea Children's Home in Kenya. In 2009 he completed an honours year at the Australian National University, working on diagnostic devices for fusion plasmas for which he was awarded a University Medal. In the first half of 2010 Mathew travelled to Kenya again, before returning to U. Tasmania where he completed a chemistry major. Currently he is working as a chemist in his family's company, Allison Laboratories, in Hobart.

Bernard Mills (1920 – 2011)

Bernard Yarnton Mills was born on 8 August 1920 in Sydney, where he died on 26 April 2011. He was educated at the University of Sydney (B.Sc. 1941, B.E. 1943, M.E. 1949, D.Sc. Engineering 1959). Along with the other five students who completed electrical engineering honours in 1942 he joined the CSIR Division of Radiophysics to work on radar research and development. After the end of WWII he remained with Radiophysics, working his way up to senior principal research officer. His first project was the successful development of a linear accelerator system for an X-ray tube.

Mills then spent some time assisting Trevor Pearcey with the development of Australia's first digital computer before joining Joseph Pawsey's radio astronomy group to work on point radio sources using an interferometer with small and large spacings. However, he realised this interferometer did not give a whole picture of what was in the sky and that resolution was more important than sensitivity for this low frequency work. He decided to build a cheap pencil beam instrument and the result was the two-dimensional Mills Cross Telescope, built at CSIRO's Fleurs field station in Badgerys Creek.

In 1960 Mills moved to the University of Sydney as reader in astrophysics and started a radio astronomy group. In 1962 he established the Molonglo Radio Observatory near Canberra. The telescope built there, the 'One Mile Cross', was used to discover some of the first pulsars in the Southern Hemisphere. From 1965 until his retirement in 1985 he was professor of astrophysics. He then had the title of emeritus professor conferred on him.

Bernie was elected a Fellow of the Australian Academy of Science in 1959 and served on the Council from 1969 to 1971. Other honours include the Academy's Lyle Medal in 1957, election to the Royal Society in 1963, the Britannica Australia Award for Science in 1967, appointment as a Companion in the Order of Australia in 1976 and a Centenary Medal in 2003. In 2006 he was awarded the Grote Reber medal which is administered by the Queen Victoria Museum in Launceston, Tasmania.

During his university days Bernie was a very keen chess player. He returned to it after the war years, with some success, but gave it up in 1950 because of work pressures. He then took up painting.

Bernie married Lerida Karmalsky in 1942 and they had three children, Eric, Miranda and Deborah (now Shamynka). After his wife's death in 1969 he married Crystal Davidson. She survives him, together with his children, two stepchildren and five grandchildren.

Ken Le Couteur (1920 – 2011)

Kenneth James Le Couteur was born in Jersey, in the Channel Islands, on 16 September 1920 and died in Canberra on 18 April 2011. He was educated at Cambridge (B.A. 1941, M.A. 1945, Ph.D. 1949), where he was the joint winner in1941 of the Mayhew Prize for distinction in applied mathematics. His studies were interrupted by WWII and he spent 1941–45 as a scientific officer in the Ministry for Aircraft Production, working at Bletchley Park, the British code-breaking station.

After completing his Ph.D., Le Couteur spent a year as a fellow in the physics department at Manchester University (1948–49), working on the evaporation theory of nuclear disintegration. He then took a senior lecturer's position at Liverpool University, where a synchrocyclotron was being built, and was promoted to reader later in his seven-year appointment. During this period he invented the 'regenerative' method of beam extraction, which collimated the external particle beam, improving its intensity 100- to 1000-fold.

In 1956 Le Couteur moved to the Australian National University as foundation professor and head of the Department of Theoretical Physics, a position he held until his retirement in 1985, when the title of emeritus professor was conferred on him. He bought the first computer for the ANU in 1960, an IBM 1620. He encouraged interaction with the experimental departments within the physics school and worked closely with the nuclear, particle and plasma groups.

Le Couteur's own research ranged from purely fundamental mathematical studies on a conjecture of Bessis concerning the partition function for quantum statistical mechanical systems to the more practical considerations of focusing and guiding charged particles by magnetic fields.

He played a very active role in building up the department, acting as head of the Research School of Physics, for extended periods on two separate occasions. His contribution to the development of not only the department but also the school was recognised by the ANU in 1996 when the mathematical sciences building was named the Le Couteur Building. He was elected to the Academy of Science in 1960 and received a Centenary Medal in 2003.

Ken was a keen sailor and built his own boat which he sailed on Lake Burley Griffin with his family. He married Enid in 1950. She survives him, together with their children Caroline, Penelope, Mary (now Avinashi), their foster daughter Marion, and two grandchildren.

[Both obituaries are reproduced (with minor style changes) courtesy of the Australian Academy of Science from its Newsletter, June 2011 – Ed.]

PRODUCT NEWS

LASTEK

Lowest Profile 3-axis Nanopositioners from Mad City Lab

MCL
MAD CITY LABS INC.

The Nano-LPQ is the lowest profile high speed XYZ nanopositioner available and offers 75×75×50 µm travel with picometer position noise under closed loop control. The Nano-LPQ features equal millisecond response times in XYZ, an integrated sample holder, analog and digital control with added scan synchronisation features, and compatibility with major image and automation software.

Designed to minimise the moving mass, lightweight sample holders are integrated into the stage and represent the only moving component. This unusual design allows the three axes of motion to have matched resonant frequencies and step response times. Equal 3-axis speed is particularly useful for applications like 3D particle tracking. The Nano-LPQ uses internal position sensors utilising proprietary PicoQ™ technology to provide absolute, repeatable position measurement with sub-nanometer resolution under closed loop control.

The Nano-LPQ is LabView™ and C++ compatible and is supplied with Mad City Labs' Nano-Route®3D software, for ease of use.

Features:

- Low profile, high speed, XYZ motion
- Built-in sample holders
- Equal speeds on all three axes
- Closed loop control

Typical applications:

- Optical microscopy, easy to retrofit
- Optical trapping experiments
- Fluorescence imaging
- Particle tracking
- Single molecule spectroscopy

The Nano-LPS Series is the lowest profile 3-axis piezo nanopositioning system suitable for applications such as super resolution (SR) microscopy and force microscopy. The Nano-LPS series continues the innovative design approach originally introduced by Mad City Labs. At only 20 mm tall with 83 mm wide centre aperture, the Nano-LPS series is designed for practical microscopy users interested in nanoscale phenomena. The Nano-LPS series features up to 300 microns of motion per axis and picometer precision under closed loop control. The low height of the Nano-LPS Series allows it to be easily integrated into existing inverted optical microscopes. Like the related Nano-LP Series, the Nano-LPS Series is ideal for demanding microscopy applications which require long range travel, fast scan rates, and three axes of motion.

Mad City Labs proprietary PicoQ™ sensors enable picometer position noise with ultra high stability, which is important for demanding applications such as SR microscopy techniques.

Features:

- Lowest profile 3-axis nanopositioner available
- Large aperture for standard 3″ slides
- 100 µm, 200 µm and 300 µm ranges of motion (XYZ) under closed loop control

Typical applications:

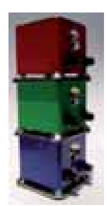
- Optical microscopy, easy to retrofit
- Optical trapping experiments
- Fluorescence imaging
- Alignment
- Single molecule spectroscopy

Ocean Optics acquires Sandhouse Design

Ocean Optics extended its product family after acquiring Sandhouse Design, LLC.

Sandhouse developed a unique line of high-powered LED light sources for research and spectroscopic applications.

These products have been widely used in biotechnology, process control and industrial applications.



LED Light Sources

These ergonomic and smartly designed fibre-coupled LED light sources are ideal for fluorescence, spectroscopy and general fibre illumination applications. The Ultra LED high-power light sources can be operated in continuous or external trigger modes. Available in UV, VIS and Infrared.

SIR Scanning Spectrometers

The SIR Scanning Spectrometer Series from Ocean Optics provides you a range of fibre-based spectral data collection in a detection instrument that is built to last and always reliable.

These SIR Scanning Spectrometers feature USB 2.0-compliant interfaces that provide fast data transfers. Plus, the included software can be used to control all of your SIR spectrometer's functions as well as analyse data.

The SIR spectrometer family includes:

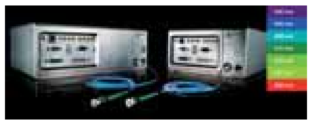
- SIR-1700: 400–1700 nm
- SIR-2600: 0.9–2.6 μm
- SIR-3400: 1.0–3.4 μm
- SIR-5000: 2.0–5.0 μm
- SIR-6500: 3.0–6.5 μm

Deep UV LEDs

Sandhouse Deep UV LEDs are available in a wide range of wavelengths and package sizes. These devices are manufactured using AlGaN/GaN technology, which enables a new generation of high band-gap energy opto-electronics devices, able to perform down to 240 nm.

LATEST NEWS FROM 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

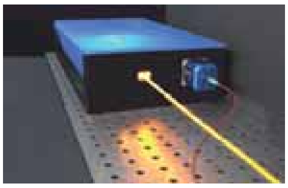
Our ultrachrome picosecond laser is:

- 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
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10 Reid St
Thebarton, SA 5031
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Web: www.lastek.com.au

WARSASH

Lightweight Benchtop Vibration Isolation

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

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

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

Designed for use in laboratories and Class 100 cleanrooms, the ELpF platform is ideal for supporting atomic force micro- scopes, 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
Web: www.warsash.com.au

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

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

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

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

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

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

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

COHERENT

Quantel release new dual-pulse later for PIV studies

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

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

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

Brilliant Q-Switched Nd:YAG Lasers

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

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

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

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

For further information please contact Paul Wardill on sales@coherent.com.au.
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Fax: +61 8 8352 2020
Web: www.coherent.com.au

CONFERENCES IN AUSTRALIA 2011–2012

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

7 October 2011
Australian Nuclear Association Biennial Conference
Sydney, NSW

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

30 November – 2 December 2011
Solomonoff 85th Memorial Conference
Melbourne, VIC

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

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

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

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

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

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- Measuring dark energy using the WiggleZ survey

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