A University of Sydney researcher’s proposal has led to a new world record for the largest quantum ‘circuit board’ ever produced - an essential component for a quantum computer made of laser light.

The international collaboration with the University of Tokyo and the Australian National University has seen the largest number of quantum systems brought together in a single component jump from 14 to 10,000.

“This transistor, invented in the mid-1940s, replaced vacuum tubes in ordinary computers with components that can be mass produced,” said Dr Nicolas Menicucci, from the University’s School of Physics. “The scalability afforded by transistors enabled the explosion in computing technology we’ve seen in the last 65 years.”

“This breakthrough promises scalable design of laser-light quantum computing hardware,” he says.

A theoretical physicist, Dr Menicucci proposed the experimental design, which was realised by researchers at the University of Tokyo, led by Professor Akira Furusawa. A journal article in Nature Photonics has just been published on the research.

A working quantum computer would exploit the mysterious properties of quantum physics, allowing the most difficult computational problems - impractical for even the fastest supercomputers - to become feasible to solve.

“Huge advances in telecommunications, physics and counterintelligence are possible when we have devices with such immense computational power.”

“The two main obstacles to creating quantum computers are the precise control of tiny quantum systems and the issue of scalability, which is the ability to make bigger and bigger quantum computers out of small parts,” said Dr Menicucci.

“We have made a breakthrough in scalability for the basic ‘circuit board’ of a quantum computer made out of laser light.”

The design proposed by Dr Menicucci allowed Professor Furusawa’s research team to construct a ‘circuit board’ of more than 10,000 quantum systems - an increase of three orders of magnitude over the nearest competing design.

“This experiment now holds the world record for the largest quantum resource ever produced in which every part can be accessed directly and individually, which is essential if it is to be useful for quantum computing.”

Dr Menicucci stressed that work remains to be done. “To take advantage of this breakthrough in scalability, we’ll need further breakthroughs in the precise control of these devices. This is the next step.”
Meanwhile, the business of teaching and research is continuing apace. A new cohort of students has arrived and enrolment numbers look very healthy.

Students are the lifeblood of any university and it is very pleasing that we continue to attract a large crop of extremely talented and motivated scientists-in-the-making.

At the end of last year we said farewell to two key members of the School’s administrative staff. Jane Conway left her position as School Administration Manager to take up a new position as General Manager of the Learning & Teaching Unit at UNSW. This is an exciting opportunity for Jane and she goes with our best wishes and our thanks for doing a terrific job over the past 18 months, during which she helped to see the School through a time of significant change.

We also said a sad farewell to Alex Green (née Viglienzon), who was with the School for nearly 11 years. Alex gave outstanding administrative support in many areas, especially in the running of the Foundation and the International Science Schools. She was also the editor of this newsletter, which has now passed into the able hands of Tom Gordon, our Science Communicator. Alex is moving to work in the University’s Office of the General Counsel and goes with our deep thanks and best wishes.

I am pleased to advise that Bernard Pailthorpe has been awarded the title of Honorary Professor. Bernard was a staff member of the School (1993–2002), including as Director of the VisLab facility. His interests include high performance computing and mathematical modelling, and it is terrific to welcome him back.

Professor Ross McPhedran has retired after a long and distinguished career. Ross has been at the School for well over 35 years, and I am delighted to announce that the University Senate has conferred upon him the title of Professor Emeritus. We look forward to Ross’s continued involvement with the School over the coming years. Indeed, it is notable that the majority of retired academic staff continue to have close associations with the School as honorary staff members and to make valuable contributions in research, teaching and student supervision. I think this says a lot about the School of Physics as an enjoyable and stimulating place to work.

Best wishes for a happy, healthy and successful 2014 to all our staff, students, alumni and friends.

TIM BEDDING, HEAD, SCHOOL OF PHYSICS

HEADLINE
HEAD OF SCHOOL REPORT
2014 is set to be another big year for the School of Physics. As I write these words in mid February, the site for the new AIN building is a hive of activity. It will be exciting to watch the building grow over the coming months.

Meanwhile, the business of teaching and research is continuing apace. A new cohort of students has arrived and enrolment numbers look very healthy.

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TIM BEDDING, HEAD, SCHOOL OF PHYSICS

BIOENERGY AUSTRALIA

PhD student Clara Tran and Professor David McKenzie from the University of Sydney, School of Physics have presented an oral presentation at the Bioenergy Australia Conference, an organisation that combines Industry, Universities and CSIRO to promote the use of and research into biofuels and won the prize for the best poster presentation.

The paper was on the use of immobilised enzymes in second generation cellulosic ethanol production, in which waste cellulose is converted to ethanol.

A continuous simultaneous saccharification (the process of breaking complex carbohydrates into simple sugars) and fermentation process will allow the reuse of enzymes and yeast cells in bioreactors together with the recycling of unreacted intermediates, potentially reduces the production cost. In a continuous flow, enzymes and yeast cells are easily washed out unless they are immobilized on carriers which can be retained inside the reactors. This motivates the investigation of enzymes and yeast cells immobilized on polymers using Plasma immersion ion implantation (PII) treatment.

“Enzyme cost and efficiency are currently the main bottleneck for second generation bioethanol technology,” said Ms Tran.

“Our technology, developed in the School, for immobilising enzymes using plasmas has attracted the attention of the big players internationally,” says Professor McKenzie.

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Italy has the world’s first commercial second generation ethanol plant and initial results are very promising (www.betarenewables.com). China is producing enzymes for biofuels and will be a big biofuel producer in the future, challenging the USA and Brazil, the world’s largest biofuel manufacturing and consuming nations.
A team lead by Professor Iver Cairns from the School of Physics has successfully launched a test satellite payload on a weather balloon.

The team includes many staff and students from the faculties of Physics and Engineering and aims to be the first completely university student satellite launched in Australia.

i-INSPIRE stands for initial Integrated Spectrograph Imaging and Radiation Explorer and through leadership and expertise from the University of Sydney, will demonstrate satellite capability, novel instrumentation, global radiation and space weather and spectrograph radiation testing.

Professor Iver Cairns, leader of the i-INSPIRE team said “We are happy to report a successful balloon test to 27 km altitude for the engineering model of University of Sydney’s i-INSPIRE spacecraft with the aid of Project Horus, experts in high altitude balloon launches.

The payload weighed less than 700 gm in mass, i-INSPIRE carries a fully photonic spectrograph Nanospec, an imager, and multiple satellite subsystems. A full set of Nanospec and imager data was obtained via the spacecraft’s successful autonomous operation. i-INSPIRE continued to transmit its beacon and take data even after landing.

Professor Tim Bedding, Head of the School of Physics said “Congratulations to everyone involved in i-INSPIRE, this is an important milestone for a very exciting project.”

Professor Bland-Hawthorn from the Astrophotonics group said “The successful balloon launch is a small, but crucial, step in convincing our international collaborators that we are able to design and build instruments that can operate at extreme altitudes.

i-INSPIRE’s balloon flight, which was Project Horus’s 30th flight, also carried a University of Sydney materials science payload (Drs Alexey Kondyurin and Marcela Bilek), and advanced GPS tracking systems developed by Project Horus.

“We have close collaborations with NASA Goddard and the Kavli Institute Santa Barbara who are heavily involved in space launches. They see our program as both novel and interesting. Australians are leading the way in the development of a new generation of ultra-compact, high performance, photonics-based instruments,” said Professor Bland-Hawthorn

“i-INSPIRE’s balloon flight is a major step towards launching into space. As such the test is a step towards Australian universities and institutions developing space capabilities,” said Professor Cairns.

These tests and launches will enable the team to take part, for instance, in the European Union’s QB50 Project and the Marabibi Constellation project in the Australian Academy of Science’s 2010 Decadal Plan for Australian Space Science.

University of Sydney students Adrian (Size) Xiao, Christopher Betters, and Jiro Funamoto played major roles in designing, building, and testing i-INSPIRE’s instruments and subsystems, together with Professor Joss Bland-Hawthorn, Dr Lisa Fogarty, Dr Sergio Leon-Saval, Dr Tony Monger, and from the Faculty of Engineering Dr Xiaofeng Wu.
The November rains filled much of the AIN construction site and significantly slowed progress for a couple of weeks. Fortunately, with pumps and hot weather, the site quickly recovered and workers were back on site in good time. This allowed Mainland Civil to complete the early works at the beginning of December, marking an important milestone in the development of the AIN building.

A 360° view of the site as it was at the end of this period can be viewed here: http://360.io/NhQdsgr

Following the end of the early works, the main contractor, Lend Lease, took possession of the site and immediately began preparations. Since then, site sheds have arrived, holes have been drilled and filled with concrete, formwork has been constructed and, as I write this, the main tower crane is being erected.

Independently of the construction work, we are beginning to think about operational readiness. This process will ensure that when the building is complete, the School, the Faculty and the University will have thought about and implemented all the necessary preparations to ensure we hit the ground running and the project is a success.
**NEWS IN BRIEF**

**DANCING WITH THE STARS - ASTRONOMY MEETS CHOREOGRAPHY AT THE SYDNEY FESTIVAL**

*AM I* is the creation of choreographer Shaun Parker in collaboration with Astronomer Dr Helen Johnston. His work explores the genesis of life, premiered at the Sydney festival.

“Shaun wanted to know about the formation of the universe, so I explained what astronomers have discovered. By observing the distant universe, and comparing those observations to detailed computer models, we now understand a surprising amount about the evolution of the universe,” Dr Johnston said.

“The universe was created in a single instant of time at the Big Bang. While it was originally enormously hot and dense, immediately after this instant the universe began to expand and cool.”

“First atomic particles were created from energy, then these particles began to swirl together to form clouds of gas, which collected to form stars and galaxies. As astronomers look out to very distant galaxies, we are looking backwards in time, and can actually see galaxies forming.”

For Dr Johnston, it was an opportunity to reveal the intricacies of astronomy and science to a new audience: “I was delighted to be involved, as one my passions is to teach people and show them what astronomers have found out about the universe.”

Dr Johnston reflected on scientists' involvement in the festival event: “As scientists, we have our own vocabulary. We use words such as energy and motion in a particular way, but of course those words mean something very different to a dancer. It is fascinating to see someone take the ideas you’ve explained and form them into something very human and recognisable.”

**TALL POPPY WINNERS**

Two School of Physics researchers Dr Dennis Stello and Dr Alex Argyros have been awarded NSW Young Tall Poppy awards in a ceremony at the powerhouse museum on October 31. This is the second year in a row that an academic from the University, and from the School of Physics, has won the award.

Dr Stello was chosen as the NSW Young Tall Poppy of the Year, while Dr Alexander Argyros, another academic from the School of Physics, won a Tall Poppy award at the ceremony held at the Powerhouse Museum last night.

“I’m excited about the great opportunities this award will give me to communicate this fascinating science and to voice the importance of science in society” says Dr Dennis Stello.

For his work studying the sounds of stars and what they reveal about their intricate inner workings, the University of Sydney’s Dr Dennis Stello has won the NSW Young Tall Poppy of the Year award. The sun and most other stars experience a continuous rumble from massive internal quakes, making them ring like big vibrating bells in the sky.

Working in a new field of astrophysics called asteroseismology Dr Stello’s research exploits the fact that each star ‘plays’ its own particular range of notes, which reveals its size, age, and composition, just like the timbre of instruments in a large orchestra.

“By following thousands of stars and studying their interior structures, I am exploring how stars like our sun grow old. This will ultimately help us understand the sun’s behaviour and potential impact on its surroundings, including conditions on Earth such as cloud formation and global temperatures,” said Dr Stello.

The research focus of award winner Dr Alexander Argyros is how light interacts with microscopic structures in materials. He works on optical fibres, with micron-sized holes running the length of the fibre, to make them more transparent, to allow faster connections, or for medical applications, such as detecting different chemicals.

“This award gives me the opportunity to raise awareness about our work, not only with the public, but also with other researchers in medicine or biology that can utilise our innovations in their research” he says. Dr Argyros recently contributed to the development of a metamaterial lens with ten times the resolution of any current lens, making it a powerful new tool for the biological sciences.

The awards ceremony was attended by more than 50 leading representatives of the science, technology, engineering and education sectors from universities, business and industry groups.

**GIANT MISALIGNMENT IN MULTI-PLANET SYSTEM**

Two University of Sydney astronomers, Tim Bedding and Dennis Stello, are part of an international team, led by their former PhD student Daniel Huber, that has discovered the first multiplanet system in which the equator of the host star is misaligned with the orbital plane of its planets. Published in the journal *Science*, the finding puts a new twist on one of the longest standing puzzles in exoplanet theory: the formation of “hot Jupiters”, giant planets in close-in orbits around their host stars.
TOP 50 PHILANTHROPIC GIFTS INCLUDE TWO AT THE UNIVERSITY OF SYDNEY

BY VERITY LEATHERDALE

The contribution to Australian society made possible by two philanthropic gifts to the University of Sydney have seen them feature in a top 50 philanthropic gifts list published on 14 October 2013.

The 50 gifts were chosen for being inspirational and having a lasting impact on Australia’s cultural and physical landscape, rather than simply for their monetary value.

Following a nomination process by the general public the list was compiled by the Top 50s Working Group, consisting of Pro Bono Australia, Philanthropy Australia, Swinburne University’s Asia-Pacific Centre for Social Investment and Philanthropy, The Myer Foundation and Sidney Myer Fund.

Projects funded by the gifts include the Heart Foundation, the Walkley Awards, the Parkes Telescope, St Vincent’s Institute of Medical Research, the Australian Indigenous Mentoring Experience, the No Interest Loan Scheme and the establishment of the Royal Botanic Gardens in Melbourne.

The two gifts associated with the University of Sydney are the Challis bequest and funding for the supercomputer SILLIAC, as outlined below.

Having arrived in Sydney with no money or expectations John Henry Challis built a fortune through real estate and as a merchant. His bequest, in 1880, of £276,000 to the University of Sydney transformed Australia’s first university. The money was used to establish chairs in anatomy, zoology, engineering, history, law, logic and mental philosophy, and modern literature.

The bequest helped the university expand into new disciplinary areas at the same time as it celebrated the potential of private endowments for the extension of knowledge.

“The power of the Challis endowment,” said Dr Michael Spence, the Vice-Chancellor and Principal of the University, “is the flexibility the gift provides, as true in 1880 as it is today, to apply the funds to exciting new initiatives for the future development of the university.”

The Challis bequest still exists and has kept pace with inflation.

The size of a double-decker bus, containing 2,800 vacuum tubes and programed with paper tape, SILLIAC was the first supercomputer built in an Australian university, in 1956. The Sydney version of the Illinois Automatic Computer was instrumental in the development of the Snowy River hydroelectric project as it was used to design dams and tunnels.

It led to the development of the first payroll system, was used by Australia Post to design telephone switching gear and by Woolworths for its first inventory studies. Most importantly it led to the development of information and communications technology studies in Australia.

The computer was created thanks to the generosity of Dr Adolph Basser who won the 1951 Melbourne Cup and donated the £50,000 prize money to the University, contributing a further £50,000 in 1954.

The dynamic new head of the University of Sydney’s School of Physics, Professor Harry Messel, had persuaded Dr Basser, who did not know much about computers, of the impressive potential of a supercomputer.
HIGH SCHOOL STUDENTS TAKE PART IN COEPP MASTERCLASS

BY PRISTINE ONG

The School of Physics ran the one-day international masterclass for forty Sydney High School students in collaboration with the Australian Research Council’s Centre of Excellence for Particle Physics at the Terascale (CoEPP) and the International Particle Physics Outreach Group.

Across Australia, almost 100 students took part in the masterclass, which also took place concurrently at the University of Adelaide and the University of Melbourne.

Particle physicists from the University’s CoEPP node, a part of the ATLAS collaboration at the Large Hadron Collider, tutored the students as they worked with real data generated from the experiment. The LHC at CERN is the world’s largest particle accelerator and recreates the conditions that occurred just after the Big Bang to explore the fundamental building blocks of the universe.

The masterclass also gave students the opportunity to connect with particle physicists around the world, including a video link with Fermilab in Chicago and a virtual visit of CERN in Geneva.

“Research on the Higgs boson is not something remote that you read about in the paper or see on the news, but happens in part right here. Our collaboration highlights the fact that here on the other side of the world to the laboratories which house these giant accelerators, Australian scientists at universities such as the University of Sydney are involved in this research,” says Director of CoEPP’s Sydney node, Associate Professor Kevin Varvell.

Professor Varvell continued: “One of the most important things the masterclass can do is to convey some the sheer wonder and excitement of fundamental science as it is carried out at places like CERN and Fermilab. We feel it as scientists but it is good to carry that out to the general public and school students.”

During their virtual tour of the ATLAS control room, Steven Goldfarb, Outreach and Education Coordinator at ATLAS, showed the students how a particular physics collaborations works. “They interact with real scientists and find out that we do not all wear lab coats and pocket protectors,” he said. “In our exchanges, we give them a more realistic description of what a career in science is like, and whether or not it is worthwhile investing all those years at university.”
Tell me a little bit about Veritasium

Veritasium is a science video blog. I started it about 3 years ago and what I really wanted to do was to communicate science to everyone and make science really beautiful and accessible. Since then it’s grown to be a YouTube channel with over a million subscribers and over 50 million views so I’m really happy with where it’s gone.

Over a million subscribers and one of the top channels in Australia

Absolutely, Veritasium is ranked about 8th in Australia which I’m really proud of and of course its one of the only really big science channels in australia or even globally. It’s ranked #7 amongst education channels, so I think it’s done really well, it’s been received really warmly by a lot of people and I think a lot of that comes down to a constant dedication to giving people the information and access to resources and ideas that they don’t normally have.

What was your path from where you were from to where you are now..What were you like at school

When I was at school I think I was one of the better students in my classes, perhaps one of the best in fact, because I was really results oriented. I always wanted to perform really well and achieve top marks. I wanted to do that to prove it to myself, I used to think to myself that I want to be ranked #1 in my school, and “what are the chances that I am the smartest kid in my school?” There were 400 kids in my class, so what I had to believe was “I can work harder, I can be more dedicated to this, I can figure it out,” and I think its that kind of dedication devotion perseverance that allowed me to achieve those top results.

What was science like at your school?

I had amazing science teachers, all the way through, I just loved science. I did all three sciences and what I really loved about them was the way they helped me understand the world. I think there’s a lot of classes where you develop valuable skills like writing, mathematics, all very important, but science because it was so clear and you could really work out whether things were true or not, that was really important to me. Whereas in history it always seemed to be a bit more of a matter of opinion. There’s something about fundamental solid truth that I find really appealing, I’m of that kind of mind.

Do you have an anecdote about a science teacher, inspired?

I had a physics teacher, who was really off the wall and I tend to believe that all great physics teachers are a little bit funny, a little bit crazy. So he would say the zaniest things, I don’t even know if I could come up with something as odd, you know sometimes it was inappropriate, but it still worked you know it was functional for the topic at hand, he was a lot of fun.

What did you study at university and why did you choose that?

For my undergraduate I studied at queens university in Canada. I studied engineering physics, so I was basically doing a lot of courses with the engineers and mechanical type labs but I was also doing heavy physics content. It was almost like a dual degree, getting the best of both worlds. I chose engineering physics because I thought it was a challenge, but I felt like it was also practical, so these two sides appeal to me. I wanted to be learning skills that were
very usable in a job market but also I wanted to be really extending myself, I wanted to be forcing myself to really keep on learning and thinking at a very high level and that degree definitely did that for me.

What made you come back to Australia do your PhD?
I did my undergrad degree in eastern Canada and it was very cold for 4 years, so after having all of that winter I decided to come back to Australia and I wanted to have a bit of an adventure. I thought about what sort of things do I want to do with my future. I’d always been very interested in science obviously, also in education. I love teaching my friends and I was also really interested in video making and media and I felt like that if I could cause all of these things to interact, that is what I wanted to do, so I ended up doing a PhD here in the school of Physics on the topic of how to make films that communicate science effectively. So I was trying to merge all of these passions together and I think it worked out really well.

Can you summarise your PhD?
The topic of my thesis was how do you make a film which effectively teaches science. What I found was, just saying the correct things and showing the best animations or real world examples we can, doesn’t really result in much learning, especially for novices. In order to communicate with people who really have never understood the subject before, you need to engage them on the level that they are, and often that is not a zero starting point, often, people come in, at least in physics, starting with ideas which are not scientific and infact they hinder learning. So I found that incorporating these alternative ideas, or misconceptions, into the videos, it actually significantly boosted the way in which student watched the video and also the way in which they learned from it. That made me realise that when we go out there to try to change opinions and help people learn, we need to start with incorrect information, you can’t just avoid it because teaching that way doesn’t work.

What was your experience of studying physics here at the University of Sydney?
I studied a few of the graduate units here at the university. Advanced quantum mechanics, and relativistic quantum mechanics, general relativity, they were quite challenging. They were great courses, I thought they were lectured by great lecturers and I really enjoyed learning from them. A lot of what I did here at the university of Sydney was independent research and that’s what I spent most of my 3 and half years doing. The independent research was really good and it was a good shift for me. I’d been doing a lot of technical things and a lot of calculations, problem sets, and then I started doing a PhD and its a very different skill set where you’re reading a lot of papers and you’re writing a lot of things, interacting with a lot of people bringing in these different concepts and setting up your own experiments. Doing the PhD was a nice shift for me and it was a really good experience I felt like I broadening my horizons and opening up my skill set, so yeah it was great!

What lessons did you take from your studies that you’ve applied to Veritasium?
I think the PhD has influenced dramatically what I do with Veritasium, for one thing a lot of my videos do focus on a misconception, they focus on things that I studied while I was here or misconceptions I had myself, there are all these areas where people think they know what’s going on, but they don’t. Doing the PhD helped me understand how to communicate with those people. Also, I practiced a lot of my video making skills while I was doing my PhD, that’s also contributed to the Veritasium project. Plus while I was doing my research I wrote a grant proposal to make videos about high school syllabus physics topics, a lot of that has contributed to what I do now. Everything that I did for my PhD has led me to this point now where I’m doing Veritasium and I think it’s made my content so much better than what it would’ve been without that additional study.

What do you do outside of Veritasium?
Outside of Veritasium, I like to play soccer, go running, go to the beach, I also read a lot about science. I like to speak about science, I like to talk to teachers about what they’re doing, I also taught for about 7 years. I feel like my life is totally encapsulated with this mission of getting to the truth of matters. So when I’m not thinking about the truth of science I’m thinking about the truth of other things, social media and the way we interact with each other for example.

What’s next for Veritasium?
I really want to take Veritasium to the next level, I want to make it bigger, I want to extend its reach and I really want to make spectacular experiments, I think that’s something that people can really get behind. I also don’t want to forget my fundamental roots which were to try to communicate science to people who don’t understand science. A lot of my audience now already love science and they just want more of it, they want more things that they’ve never heard about before and really explained clearly. I want to engage that audience as well as engage an audience which is younger viewers, people who haven’t had a background in science etc, I want to be able to teach them as well and really make use of those skills that I’ve gathered over the years.

PHYSICS ALUMNI – WE WANT TO HEAR YOUR STORY...
When you were at School of Physics did you ever wonder where your studies would take you? What path your career would follow and how you’d get to where you are today? We want to know where your degree has taken you and invite you to share your story with us.
Alumni are vital to our ongoing success and actively contribute to the School’s future; through inspiring future generations; and sharing knowledge and experience.
If you would like to have your story profiled in Physics News and/or on the Physics website please contact Tom Gordon on 9351 3201 or tom.gordon@sydney.edu.au
Welcome back, and bring on 2014!

Firstly, Info day was a great success. I’d like to thank Anne Green, Joe Khachan, John O’Byrne, Helen Johnston, Dick Hunstead, Manju Sharma, and Mike Wheatland for their time helping answer students’ and parents’ questions about studying Physics at Sydney Uni. The day went off without an issue, but we did have a couple of close calls with the chaotic pendulum that was on the table. It was nearly a concussion point, instead of a discussion point!

Outreach in brief:
– Helen Johnston has collaborated with Artist Shaun Parker to create a dance piece called AM I that is being premiered at the Sydney Festival. An article about the collaboration is here. From all accounts, the show is extremely good!
– Michael Biercuk appeared be on ABC News Breakfast doing a segment on 14 Jan. He’ll be talking about the latest stories of the day in in a newspaper rundown and flying the flag for physics and science!
– John O’Byrne and Dick Hunstead made some comments about the HSC physics syllabus and the Board of Studies published in the Sydney Morning Herald on January 4. It’s an interesting read, quite thought-provoking and topical at the moment.
– The Outreach Committee will be reformed in 2014 continuing the discussion with respect to outreach and reflecting the newly created outreach strategic plan. The Committee will focus on a range of Outreach areas and agenda items from Outreach activities and programs, to inreach, websites and strategic communications amongst other things.

Kickstart
Kickstart is the largest outreach program run by the school of Physics. It consists of a 2.5-hour session where physics students conduct experiments as outlined in their physics syllabus. Altogether in 2013, the program saw 3207.

Kickstart has been running continuously since 2005. Numbers have more than doubled since then.

Kickstart in 2013 was a record breaking year and it looks like it will be getting bigger in 2014. Here are some highlights from last year
– Students in 2013 – 3251
– Sessions in 2013 – 220
– Schools in 2013 – 161
– Average of 77 students per week
– Average of 162 students per week in busiest term
– Term 2 was the busiest term
– 30% of schools come to Kickstart for more than 1 session
– Most popular session – Ideas to Implementations (78 sessions, 36% of all sessions)

Work Experience
For science week, I had a work experience student, Anna Matchett from SCEGGS Darlinghurst join the team and experience some of the roles and responsibilities of working at Sydney University School of Physics. Anna helped with projects for resources and learning, research, she went to meetings and lectures and even got to see in some of the labs.

Our main task was to design and construct a funnel for solar observations using the Kickstart telescope. The process was enjoyable and documented for anyone else who wants to have a go at it. The whole project took about 2.5 hours and cost just under $50 (assuming you have a telescope already!) I now us the solar funnel at every opportunity that I can.
Tens of millions of stars and galaxies, among them hundreds of thousands that are unexpectedly fading or brightening, have been catalogued properly for the first time.

Professor Bryan Gaensler, Director of the ARC Centre of Excellence for All-sky Astrophysics (CAASTRO) based in the School of Physics at the University of Sydney, Australia, and Dr Greg Madsen at the University of Cambridge, undertook this formidable challenge by combining photographic and digital data from two major astronomical surveys of the sky, separated by sixty years.

The new precision catalogue has just been published in The Astrophysical Journal Supplement Series. It represents one of the most comprehensive and accurate compilations of stars and galaxies ever produced, covering 35 percent of the sky and using data going back as far as 1949.

Professor Gaensler and Dr Madsen began by re-examining a collection of 7400 old photographic plates, which had previously been combined by the US Naval Observatory into a catalogue of more than one billion stars and galaxies.

“This catalogue comes at just the right moment for the next generation of telescopes. Using our measurements, astronomers who find interesting new stars in the sky can essentially go back in time, and see what the object they’re studying was doing 60 years earlier,” says Professor Gaensler.

The astronomers then set out to painstakingly match all the objects in this catalogue with more modern measurements from the Sloan Digital Sky Survey. Using very stringent criteria to be absolutely sure of a match, Professor Gaensler and Dr Madsen produced a final catalogue of 44 million stars and galaxies that had definitely been seen twice: both in old photographs and with modern cameras.

“Thanks to clever computer algorithms, we thankfully didn’t need to inspect all 44 billion stars and galaxies individually,” said Professor Gaensler. “But even so, processing the data and then testing everything to make sure we got it right took us more than a year.”

“This cosmic game of snap provides two important breakthroughs. First, it gives far more accurate measurements of the brightness of each individual star than had ever previously been possible. Second, by comparing two photographs of each star taken up to sixty years apart, it becomes easy to identify stars whose brightness has slowly changed.”

The researchers found that approximately 250,000 objects in their new catalogue, or about 0.6 percent of all the stars in the sky, change in their brightness by quite large amounts over a human lifetime.

Some of these discoveries appear to be new cases of stars known as ‘Mira variables’: red giants in a late stage of stellar evolution that pulsate in brightness before collapsing into a dense white dwarf. Other stars are likely to be exhibiting rare and unusual behaviour that has never previously been identified.

“What is special about this catalogue is that it carefully combines historical data with modern measurements. This is a unique way to study objects that gradually change over years or even decades,” says Dr Madsen.

The researchers are making their entire catalogue public on the internet, in the lead-up to the next generation of telescopes designed to search for changes in the night sky, such as the Panoramic Survey Telescope and Rapid Response System in Hawaii and the SkyMapper telescope in Australia.
WHERE DOES ALL THE GOLD COME FROM?

BY DR KARL KRUSZELNICKI, JULIUS SUMNER MILLER FELLOW

The seasons roll around, and when autumn comes, some of the trees take on a gorgeous golden colour. But some Australian trees actually concentrate gold, that precious metal, into their leaves. How did the gold get there? The answer involves exploding stars, asteroids, bacteria, earthquakes, and lots of geology.

All the gold ever mined would fit into a cube less than 21 metres on each side. Gold is a ‘precious metal’, with a price up around $60,000 per kilogram.

Today, about half of it is used in jewellery, about 40 per cent for financial investments, and about 10 per cent for industrial uses.

Gold has many wonderful properties — it is a very soft and easy to work and turn into jewellery; it is a great reflector of heat and so it’s used as a thin film on windows; and it’s a great conductor of electricity and pretty inert so it won’t corrode when used in electrical circuits.

And because it is so inert, back in the old days (several thousand years ago) people would find lumps of gold just lying around on the ground, still shiny and bright after thousands or millions of years out in the weather. But where did it come from?

In the beginning was the Big Bang, some 13.8 billion years ago. At the start, the Universe was so hot that everything was pure energy, and there was no matter. As the Universe expanded and cooled down, the first atoms coalesced. About 90 per cent of them were hydrogen atoms, about 10 per cent helium atoms — with a tiny fraction of other lighter elements. At this early stage, there was no gold anywhere in the Universe.

A few hundred million years after the Big Bang, the first stars were blazing away with their nuclear fires. These nuclear fires forced lighter elements together to make slightly heavier elements, and these nuclear reactions released a huge amount of energy. Gradually, these early stars began making elements such as carbon, nitrogen, oxygen — working their way up through the periodic table towards iron. And still, there was no gold in the Universe.

As these early stars ran out of the lighter elements, they began burning heavier elements. Finally, as they burnt silicon to make iron, they exploded as a supernova, and for a few short moments, each star would release as much energy as all the regular stars in that galaxy put together.

In that cataclysmic explosion, for the first time, atoms of gold were manufactured — and then hurled out into the Universe, along with the other debris from that explosion. It also seems that gold may be created when neutron stars collide.

Over time, vast clouds of gas and dust from these explosions began to coalesce thanks to the attractive force of gravity — and they formed what we called ‘stellar nurseries’. A stellar nursery is a location where solar systems are born.

Once one part of the gas and dust had become more concentrated and more dense, its gravity attracted further gas and dust.

About 4.6 billion years ago, a rather special spherical cloud evolved into a slowly spinning flattened disc. This would be our solar system. After about 10,000 years, this disc had gradually separated out into little lumps about 10 kilometres across called planetismals.

Over the next 100,000 to million years-or-so, these 10-kilometre sized planetismals collided and stuck together to form smallish planets ranging in size from Moon-size to Mars-size. Then, over the next 10 to 100 million years, the larger planets would have formed. Specifically, in the case of the Earth, it would have taken about 30 million years.

However, the majority of the gas and dust would have collected at the centre of this spinning disc to form what would become the Sun. Once enough matter had accumulated here, the temperature at the centre of this Sun-to-be would get hot enough for nuclear fusion to happen. The nuclear fires ignited, and the now-hot Sun at the centre of this spinning disc of planets and gas and dust blew the gas and dust away - leaving behind our newborn solar system.

Looking at the early Earth, there would have been no solid crust — instead, the surface was covered by a sea of molten rock. The heavy elements would have melted and sunk — ending up in the iron-rich core. Today, there’s enough gold in the core to lay down a half-metre thick crust over our planet.

But, if the heavy metals sank down to the core, how come there’s still some gold left near the surface, and how on Earth did it get into Australian eucalyptus trees? Well, I’ll talk about that, next time...