The Bulletin 394

The Royal Society of New South Wales

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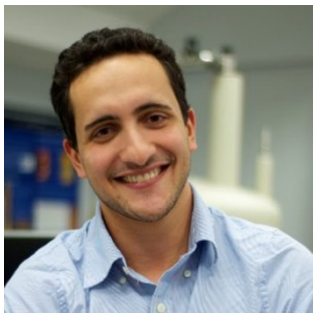
While the Society's Events for 2016 are being finalised, may all the fellows, members, and friends of the Society enjoy a happy and safe Holiday Season

Patron of The Royal Society of NSW
His Excellency General The Honourable
David Hurley AC DSC (Ret'd)
Governor of New South Wales

PUBLIC LECTURE – Wednesday, 2 December 2015

"From Quantum Devices to Quantum Machines"



James Colless
School of Physics, University of Sydney

Winner of the Royal Society of New South Wales Jak Kelly Scholarship Award for 2015

Followed by

The Society's Christmas Party

Union, Universities, & Schools Club, 25 Bent St, Sydney
***6:00 for 6:30 pm**, Welcome drink at 6:00 pm*
Fellows & Members $35; Guests, $40
Please note dress code: jacket and tie

All are welcome. To Reserve a place, email the Society at royalsoc@royalsoc.org.au

Go to Page 4 for information about the Jak Kelly Award, James Colless, and his talk

From the President

It's hard to believe that this is the last Bulletin of the year. This has been one of the most successful that the Society has had for some time – a very interesting and wide-ranging programme of events; a most successful Forum held at Government House, Sydney, in conjunction with the four national Academies; a truly outstanding field of nominees for the Society's awards; and strongly growing membership. The Council is confident that we can continue this momentum into 2016.

The Society is enormously proud of its recently-elected Distinguished Fellow, the Hon Emeritus Professor Peter Baume AC. His citation reads "An expertise and passion for community health and medicine has been consistently expressed through practice, research, teaching, university leadership, Federal Parliamentary portfolios and leadership of new national organisations on urgent issues such as AIDS and anti-doping". Peter has made an enormous contribution to Australia over a long and distinguished lifetime. He is a particularly worthy addition to the Society's ranks of Distinguished Fellows and we congratulate him on his election.

On Tuesday, 17 November, the Jak Kelly Award presentations took place at Sydney University. This award is made jointly with the Australian Institute of Physics in memory of Professor Jak Kelly, a former President of the Society. The winner this year was James Colless of the School of Physics, University of Sydney, for his presentation "From Quantum Devices to Quantum Machines". James will be giving a presentation immediately before the Christmas party on Wednesday 2 December.

We are pleased that our new website has been finished and will become live in the last week of November. In addition to its modern appearance, its functionality has been greatly improved and further developments will be introduced in coming months.

The Council also just finished work on its White Paper that aims to define the direction of the Society over the next several years. You may recall that we discussed the first draft of this at the AGM and there have been several iterations worked on by the Council over the last several months. We expect this to be circulated to members before Christmas.

I look forward to seeing you at the December meeting to celebrate a particularly successful year for the Society. As always, I am easily contacted by email at president@royalsoc.all.au and would like to hear from you.

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Report of 19 November 2015
Meeting of the Royal Society
Southern Highlands Branch

Overview of Forensic Investigation within the NSW Police Force
Senior Sergeant Charles Agius

It was a pleasure to see the enjoyment of the 75 audience members attending the last lecture of the year at the Southern Highlands Branch of the Royal Society. Senior Sergeant Charles Agius presented an excellent overview of Forensic Investigation from the earliest records of that science to the present day situation where real time forensics are being developed and employed to astonishing effect.

As early as the 8th century, the Chinese were using fingerprints to establish the identity of documents and clay sculpture. Although the fingerprints were able to be compared, there was at that time no attempt to create a formal classification system. Several hundred years later, Quintilian, a lawyer in the Roman courts, showed circa 1000 that bloody palm prints were meant to frame a blind man for his mother's murder. This was the first recorded genuine use of forensic evidence in a formal court of law.

Snr Sgt Agius spent some time speaking of the "principle of exchange", one of the fundamentals of Forensic Science. This term first appeared in 1940 in *Police and Crime Detection*, having been adapted from Dr Edmond Locard's observations. Dr. Locard (1877-1966) observed that it is impossible for a criminal to act without leaving traces of his presence. The "principal of exchange" which followed his observations dictated that when two objects come into contact with each other, each will take something from the other object, or leave something behind.

Seven years later, in the case of Harris vs. United States 331 US 145, the"principle of exchange" was relied upon in testimony in a very powerful quote: "Wherever he steps, whatever he touches, whatever he leaves, even unconsciously, will serve as silent witness against him. Not only his fingerprints or his footprints, but his hair, the fibres from his clothes, the glass he breaks, the tool marks he leaves, the paint he scratches, the blood or semen he deposits or collects – all of these bear mute witness against him. This is evidence that does not forget. It is not confused by the excitement of the moment. It is not absent because human witnesses are…"

As early as 1853, Ludwig Teichmann in Krakow developed the first microscopic crystal test for haemoglobin using hemin crystals. By 1913, Victor Balthazard, professor of forensic medicine at the Sorbonne, published the first article on individualizing bullet markings. In 1984, Sir Alec Jeffreys developed the first DNA profiling test. It involved detection of a multilocus RFLP pattern. These findings were published in 1985. A year later, Jeffreys used DNA profiling to identify Colin Pitchfork as the murderer of two young girls in the English Midlands. Significantly, in the course of the investigation, DNA was first used to exonerate an innocent suspect.

Snr Sgt Charles Agius was originally requested to give a lecture of approximately 40-50 minutes duration, but as the audience became more and more involved with his subject matter, it became abundantly clear that the original time guidelines could not be applied. The lecture proceeded for twice as long, much to the appreciation of all attending. One subject which consumed a great deal of lecture time related to fire dynamics, where videos were shown of the origin and cause of fires, and the forensic investigations that ensued in particular cases after a devastating event. A video that will stay in the minds of all attending was a real time record of a fire originating from a Christmas tree light, where in exactly 48 seconds, the entire room was engulfed in flame and completely destroyed. Agius 'commentary throughout the sequence gave vivid description of the physics and chemistry of the situation.

It must be recognized that in this far-ranging and informative lecture, a description such as this is far from adequate. The audience was delighted to hear that Charles presents lectures such as these to young students at early university level, where the significance of physics, chemistry and mathematics studies is presented as a wonderful invitation to a fascinating career in science.

Anne Wood B.Sc.(Hons) Dip.Ed

The Jak Kelly Award 2015

James Colless, winner 2015 Jak Kelly Award

The Jak Kelly Award

The Jak Kelly Award was created in honour of Professor Jak Kelly, who was Professor of Physics at The University of Sydney and UNSW and also President of the Royal Society. Its purpose is to encourage excellence in postgraduate research in Physics.

The Jak Kelly Award is supported by the Royal Society of NSW and the Australian Institute of Physics, NSW Branch. The winner is selected from a short list of candidates who made presentations at a recent meeting of the Australian Institute of Physics, NSW Branch.

James Colless's Talk

Quantum computing, the use of quantum phenomena to process information, has begun the long journey from hypothetical possibility to real-world applications. In the same way that the theoretical development of quantum mechanics fundamentally changed the way in which we understand the universe, quantum computing offers the potential to revolutionize the way in which we are able to interact with it. In particular, this counter-intuitive nanoscale world of superposition and entanglement may allow previously intractable computational problems to be solved efficiently.

The fundamental building blocks of a quantum information processor are isolated quantum mechanical two-level systems known as quantum bits or 'qubits'. Ideally such systems are easy to manipulate while being decoupled from noise in their local environment – goals that are often contradictory. In order to outperform their classical cousins at meaningful tasks quantum computers will conservatively require the control of thousands to millions of qubits. While this is still orders of magnitude less than the billions of transistors on a modern microprocessor, it is still far beyond what is currently possible.

This talk explores the complexity of scaling quantum processors and discusses new techniques and hardware developed to meet these challenges. In particular, new methods of readout are developed that allow the dispersive sensing of single-electrons using integrated sensors and the capability to read out multiple qubits simultaneously. A scalable control scheme is also demonstrated allowing large numbers of qubits to be manipulated with a small number of input signals.

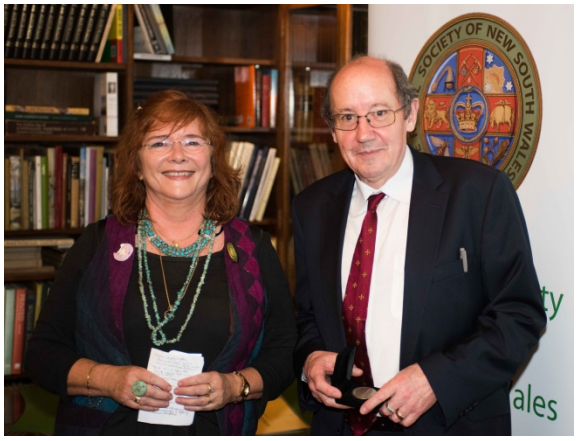
James Colless

James Colless is a postgraduate student at the University of Sydney currently undertaking his PhD under the supervision of Professor David Reilly. His research focus is readout and control techniques for GaAs spin qubits. James hopes his research will influence the design and fabrication of reliable multiqubit gates.

Report of 4 November 2015
1238th Ordinary General Meeting of the Royal Society of New South Wales

"Big History: Framing the Anthropocene"

Distinguished Professor David Christian FRSN
Big History Institute, Macquarie University



Prof. Louise Young FRSN presenting a gift on behalf of the Society to Prof. Christian FRSN

Since the beginnings of human history, taking stories from the past and synthesising them has delivered far more than the sum of the parts – it is an enormously powerful way that humans use to place themselves in context. All human societies use this approach to create origin-stories that define their place in the world. Astronomy, geology, biology, human history, anthropology, taken within the context of prehistory, ancient history and modern history can create an enormously rich origin-story for modern civilisation. Indeed, when modern science is brought to bear, this becomes even more powerful.

Our universe is about 13.8 billion years old. It is thought that within seconds of the Big Bang an almost-instantaneous inflation took place, causing the universe to begin expanding, which continues and indeed accelerates. A consequence of this expansion (as described in the "Second Law of Thermodynamics") is that complexity continues to increase. Stars formed, some exploded causing formation of the elements, these gradually came together to form new stars and planets and, at least on one planet in the universe, life evolved.

To put this in context, the Earth is about 4.5 billion years old, life began about 1 billion years later, with more sophisticated life forms not appearing until about 500 million years ago. To give some sense of scale to these enormous numbers, if the age of the universe were 13.8 years, then the Earth formed about 5 years ago, the more sophisticated forms of life such as insects, plants and other animals started to form 3–5 months ago, the asteroid that wiped out the dinosaurs hit 2½ weeks ago, and humans have only been around a day or two.

Professor Christian describes human history as a sequence of "thresholds" – the Big Bang, the influence of gravity, the formation of chemicals, and so on. The fifth of these was the formation of life forms. They are distinctive because they are complex adaptive systems that can respond to unpredictable changes in their environment. To successfully adapt, life forms have developed DNA, which provides the capacity to store, manage, and pass information to subsequent generations. In addition, humans have developed language as an additional means of information transmission. In turn, according to the Second Law of Thermodynamics, energy is required to overcome the natural tendency toward disorder. As humans have progressively learned to use the energy from the sunlight, initially through farming, and stored energy in wood, fossil fuels, and nuclear power, the capacity of humans to control information has risen, lately exponentially.

Hence, at the heart of life is energy and information. We now have so much energy and so much information that it is potentially enough to destroy the biosphere. The question is do we have the capacity and the wisdom now to control this?

Distinguished Fellowship to be Awarded to The Hon Emeritus Professor Peter Baume AC

The Hon Emeritus Professor Peter Baume AC is to be made a Distinguished Fellow of the Royal Society of New South Wales. He has made sustained, distinguished contributions to New South Wales and indeed all of Australia in medicine, academia, and public service. He was appointed an Officer in the Order of Australia in 1992 and a Companion in 2008.

After graduating in medicine from the University of Sydney in 1959, he trained and practiced in gastroenterology in the United States and England, as well as in Australia, particularly at the Royal North Shore Hospital. He obtained his MD from the University of Sydney and has been admitted to the Fellowship of the Royal Australasian College of Physicians. He has made numerous professional contributions to the medical profession and medical research.

In academia, he has held clinical academic posts at the University of Sydney and was a visiting part-time Lecturer in Physiology. From 1991 to 2000 at the University of New South Wales, he was Professor of Community Medicine and twice Head of School. He was made an Emeritus Professor in 1999 and reappointed as a Conjoint Professor in 2007. He continues to assist in training of medical students.

In addition to his ongoing contributions to academic medicine, he has served academia at the highest levels. Most notably, from 1986 to 2006, he served on the Council of the Australian National University, where he was Chancellor from 1994 to 2006.

Prof Baume has also had a distinguished career in public service. From 1974 to 1991, he served as a Senator for New South Wales. He was successively Government Deputy-Whip, Government Whip, Minister for Aboriginal Affairs, Minister Assisting the Minister for National Development and Energy, Minister for Health, Minister for Education, and a Minister in the Cabinet. Later, he was a member of the Opposition Executive. Since leaving the Senate, he has served on and chaired government committees of the Commonwealth, Australian Capital Territory, and of New South Wales.

Postgraduate Awards Day Report

The NSW Branch of the Australian Institute of Physics in conjunction with the Royal Society of NSW held its annual Postgraduate Awards Day on Tuesday 17 November 2015 at Trinity Grammar School.

The judging panel, which included Society members Prof Michael Burton FRSN and Dr. Erik Aslaksen, awarded a prize to each of the following postgraduate students nominated by their respective universities:

- **Katie Chong**, Australian National University, Research School of Physics and Engineering - Shaping Light with Optics v2.0
- **James Colless**, University of Sydney, School of Physics - From Quantum Devices to Quantum Machines
- **Michael Cowley,** Macquarie University, Department of Physics and Astronomy - Do supermassive black holes impact a galaxy's ability to form new stars?
- **Yevgeny Stadnik**, University of New South Wales, School of Physics - Manifestations of Dark Matter and Variation of Fundamental Constants in Atoms and Astrophysical Phenomena
- **Frederick Wells**, University of Wollongong, School of Physics – High Speed Magneto-Optical Imaging of Superconducting Thin Films.

Dr Amanda Bauer from the Australian Astronomical Observatory (AAO was awarded) the Community Outreach to Physics Award in 2015 for her contributions toward advancing the understanding and appreciation of science among the public. She was particularly commended for using her vast experience in outreach to help other scientists improve their own science communication skills.

The awards presentation was followed by an invited talk by Professor Michael Burton FRSN on the topic "Interstellar Explorers – mapping the molecular clouds of the southern Milky Way". Professor

Yevgeny Stadnik, Michael Cowley, Katie Chong (2015 AIP Post Graduate Award Winner), James Colless (2015 RSNSW Jak Kelly Award Winner) and Frederick Wells

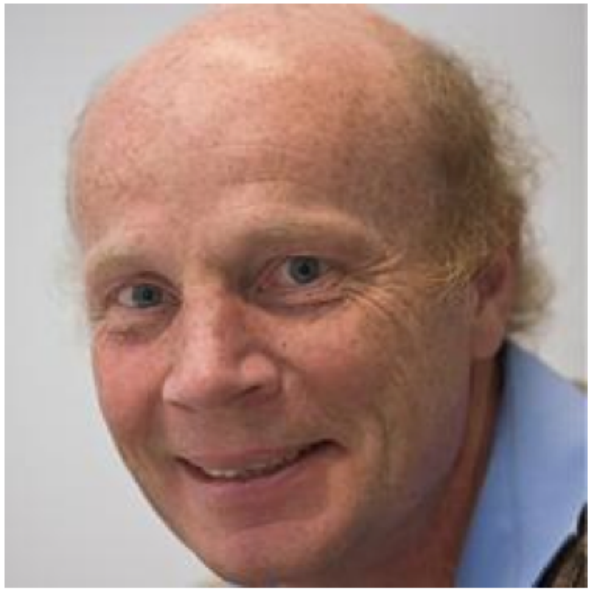
Burton is an astronomer in the School of Physics at UNSW, where he is the Director of Teaching. He researches star formation and molecular clouds, using infrared and millimetre-wave telescopes. He has pioneered the development of astronomy on the Antarctic plateau. He is Vice President of the International Astronomical Union's Division B (Facilities) and is also the Editor of the Royal Society of NSW's Journal

Prof Burton has kindly provided a summary of his talk as follows:

Giant clouds of molecular gas are the engine room that drives our Galaxy's ecology - the continual cycle of material between the gas and the stars in our Galaxy that determines its future evolution. Stars are born in such clouds, through gravitational collapse in their densest portions. The richest regions of star formation are seen from the southern skies - the brilliant Milky Way, whose very centre passes overheard every day. The ecology can be examined by following the Galactic carbon trail – measuring the element carbon emitting from its

Continued on page 8

Postgraduate Awards Day Report (Continued)



Prof. Michael Burton FRSN

principal forms as it transforms between phases within giant clouds of gas – as these are formed and dissipated on the journey of matter through the life cycle of the interstellar medium.Australian radio telescopes have led the exploration of the gas of the southern Milky Way, charting its principal atomic and molecular components. This talk described the latest exploration of the molecular medium of our Galaxy, being undertaken with the Mopra millimetre-wave telescope at Siding Spring Observatory near Coonabarabran in NSW. With an order of magnitude better angular and spectral resolution than the currently available best view of the southern skies, Mopra is opening a new vista of our Galaxy, unveiling the structure, distribution and dynamics of its molecular clouds. The survey is aiming to provide a legacy data base of the Fourth Quadrant of the Galaxy that can serve as the basis for a wide variety of investigations in the physics of the interstellar medium and the formation of stars. A window into space has been opened to measure the element carbon in the gas through its emission lines in the terahertz (THz) portion of the spectrum, using a remarkable new telescope we have deployed to the very summit of the Antarctic plateau – the HEAT telescope at Ridge A. This is the driest location on our planet and the only place where the atmosphere routinely transmits radiation at these frequencies, where the key carbon lines emit. The talk described the voyage of Galactic exploration that is underway, where it is going, and the challenges that lie ahead.

Public Website for Team Mopra: www.teammopra.org