The Bulletin 376

The Royal Society of New South Wales

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Future Events

Wednesday 7 May 2014
Annual Dinner, presentation of Awards and Royal Society of NSW Distinguished Fellows Lecture
Speaker:
Professor Barry Jones AO
Union, University & Schools Club
25 Bent St, Sydney
6:30 for 7:00 pm

Tuesday 13 May 2014
Joint meeting with AIP, RACI
The Australian Synchotron in the International Year of Crystallography
ANSTO Discovery Centre
New Illawarra Rd
Lucas Heights
Time: to be advised

Wednesday 4 June 2014
1221st Ordinary General Meeting
Lessons learnt? The Global Financial Crisis six years on
Speaker:
Professor Robert Marks
Union, University & Schools Club
25 Bent St, Sydney
6:30 for 7:00 pm

SOUTHERN HIGHLANDS BRANCH
Thursday 17 April 2014
Update on Laser Technology
Delivered by:
Professor Ken Baldwin
The Performing Arts Centre,
Chevalier College, Bowral
6:30pm

For more upcoming events see website
www.royalsoc.org.au

Patron of The Royal Society of NSW
Her Excellency Professor Marie Bashir AC CVO Governor of NSW

Thursday 27 February
Questions about power in NSW

At the annual Four Societies Lecture, Professor Mary O'Kane considered the major questions that face NSW in the future of energy production and utilisation. Asking the right questions is key – it reduces the time taken to identify the best solutions.

Australia is the ninth largest energy producer in the world and one of only four net energy exporters. We have 38% of the world's uranium, 9% of the world's coal and 2% of the world's gas. In terms of consumption, agriculture takes 3%, mining 13.5%, manufacturing and construction 25%, transportation 38% and residential about 11%. The 2014 Commonwealth Energy White Paper is seeking to address a number of questions regarding Australia's energy future. These include security of energy sources, the role of government and regulatory implications, growth and investment, trade in international relations, productivity and efficiency and alternative and emerging energy sources and technologies.

A recent report by the Grattan Institute identified a number of important issues. Australia has a lot of gas and coal, yet has yet to fully consider the impact of having no clear climate change policy. There is also the question of how can the electrical system (particularly one based on large generation units interconnected by a grid) meet the challenge of occasional very high peak demand. The Grattan Institute also posed questions around the balance of market and regulation and the importance of getting this right and explored the implications of new technologies and whether these provide potential solutions.

Australia is not unique in facing these challenges. One approach being taken in the US has been to establish an energy agency using a model was originally conceived for advanced research projects for the defence industry. ARPA-E, or the Advanced Research Projects Agency-Energy and was established to fund high risk/high reward research to identify new technologies for energy in the US. The research programmes in their portfolio relate to reconceiving the grid, the impact of micro grids, the impact of analysing big data, the gas revolution, new ways to get higher efficiencies, entirely new technologies, the best policy settings to encourage the adoption of new technologies and innovative models for research and development. Perhaps these sorts of approaches need to be utilised in NSW.

Questions that need to be addressed are what about nuclear energy? To what extent is geothermal energy applicable? How should we gain new efficiencies? How can we better optimise grid storage and geometry? What are the downsides of these various technologies? Are there opportunities to directly and export to our immediate neighbours (e.g. Indonesia)? How effective is Australia's energy R&D?

Professor O'Kane summarised the issues in three searching questions. First, how do we characterise a system that we want and the process to realise it? (What are the most important characteristics that our energy future must have, would be nice to have? What energy futures do we definitely not

(Continued on page 5)

Big data knowledge discovery: machine learning meets natural science

Report of meeting held on Wednesday, 5 March 2014

Professor Hugh Durrant-Whyte FRS, CEO, National ICT Australia

Hugh Durrant-Whyte is an internationally-recognised expert on the analysis of "big data" – the mass of information that is being generated around current information and communication technologies. Much of this is "metadata" – data that is captured as part of some activity (for example, when a digital photograph is taken also recording camera settings, capture date etc or the data kept by telecommunication companies every time a mobile phone call is made).

2.5×10^{18} bytes of data are generated every day – there is immense value in mining this data but this requires sophisticated analytical techniques. "Data analytics" is the term coined for technologies to analyse this data in areas as varied as the finance industry, the health industry, planning infrastructure, failure analysis in mechanical and electronic equipment and environmental analysis, to name but a few examples. Data analytics utilises Bayesian probability theory (named after Rev Thomas Bayes, an 18th century mathematician) to prepare quantitative models of existing data, gathering new data to address remaining problems and then updating model to incorporate both the old and new data.

Data analytics can be modelled using three types of mathematical functions: discrete functions that describe, for example, events or people's actions; finite probability functions, such as signals or locations and infinite probability functions such as spatial fields or temporal fields. As the masses of data available increase, the analysis can converge on knowledge. For example, payment patterns exhibited by individuals can be aggregated to behaviours of bank branch customers, giving an understanding of consumer behaviour. On the other side of the table, customers can utilise masses of data to take advantage of the best deals available or to customise internet-based content that they may wish to buy.

Where masses of historical data are available (for example, managing water assets) readily available historical parameters can be analysed for such applications as predicting equipment failures. In the case of water asset management, pipe age, soil type etc can be analysed to give a probabilistic analysis of when a water main might fail.

The mining industry has invested large amounts of money in developing systems to utilise masses of existing information to automate mine operation. This can take all available data around the surface of the mine, the subsurface, mapping, drilling, to create a completely integrated data model into a single, real-time representation of the mine.

The purpose of National ICT Australia (NICTA) is to utilise these data analytics approaches to produce leading-edge technologies and models for such varied applications as financial modelling, creating large-scale fully integrated data maps of regions (perhaps even as large as continental Australia). There is also a particular focus on data-driven discovery in the natural sciences in applications as varied as modelling ancient plate tectonics to predict mineralisation (on a timeframe of as much is 1.5 billion years) or ecological modelling, for example, predicting the growth of trees. Ultimately, these may be able to be integrated into one massive model of the Australian continent.

Southern Highlands Branch

Report of April Meeting 2014

Using Lasers to Create the Coldest Stuff in the Universe

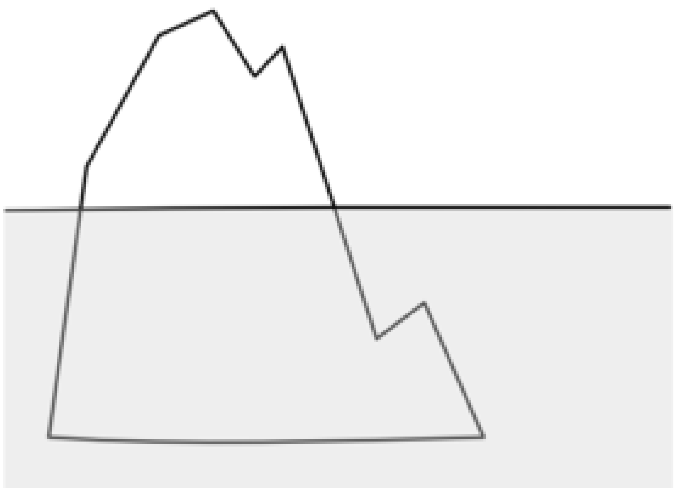
Prof. Ken Baldwin

Director of the ANU Energy Change Institute, Deputy Director, Research School of Physics and Engineering, ANU

Dr Baldwin opened his lecture to the 35 attendees with the comparison between the coldest place in the universe, the Boomerang Nebula (approx 1K or -272C), and the coldest man-made object, a Bose-Einstein condensate (BEC) at 0.45 nK. Even the coldest depths of space are a billion times too hot for a BEC to exist because of residual radiation from the big bang. BECs represent an entirely new state of matter not found naturally anywhere in the universe.

In 1925, based on work by Satyendra Nath Bose, Albert Einstein proposed that if one could make a collection of atoms cold enough, they would condense into a single quantum state making each atom identical to its neighbours in a similar way to photons in a laser beam. It wasn't until 70 years later that scientists were able to actually create the world's first BEC in the laboratory.

Scientists at the ANU have recently become only one of four groups in the world to develop a novel laser cooling apparatus capable of creating BECs using excited helium atoms rather than atoms in the ground state. The advantage of using excited atoms in the BEC is that they can be detected individually because they decay to their ground state on contact with a detector, the energy thereby released liberating an electron and producing a detectable signal in the process. The ANU team is hopeful that this newly commissioned system will yield vital clues to the mechanism of BEC formation.



In one of the most explicit demonstrations of wave-particle duality, Dr Baldwin described how his group had successfully guided atoms in a laser light beam, the atoms displaying the same properties as light guided in an optical fibre. The team cooled helium atoms to ultracold temperatures – just one millionth of a degree above absolute zero – then dropped them into a laser light beam focused on the atom cloud. The experiments which followed were based on analysis of speckle patterns.

Optical speckle is a well-studied property of light where, in an optic fibre, speckle is created through interactions between waves of the same frequency, but with different phases and amplitudes. These waves combine, or interfere, to create a wave with randomly varying intensity. While many other wave properties of atoms have been observed before, atomic speckle had remained elusive until Ken Baldwin and his colleagues guided atoms in a laser light to create the tell-tale grainy pattern of speckle.

Astonishing as it may seem, Professor Baldwin has now produced a DVD aimed at year 8 students throughout Australia, where the creation and properties of BECs are presented in a simplified, yet readily understandable format.

The history of physics is full of examples of strange and exotic phenomena that, having been developed out of pure curiosity, have gone on to spawn unimaginable technological advances. Lasers, X-rays and transistors all belong to this family and BECs may well be its newest member. The helium BEC project is part of the ARC Centre for Excellence for Quantum-Atom optics.

Anne Wood

Vale, Dan O'Connor.

It is with sadness the Society notes the recent passing of former President (1998) Dan J O'Connor.

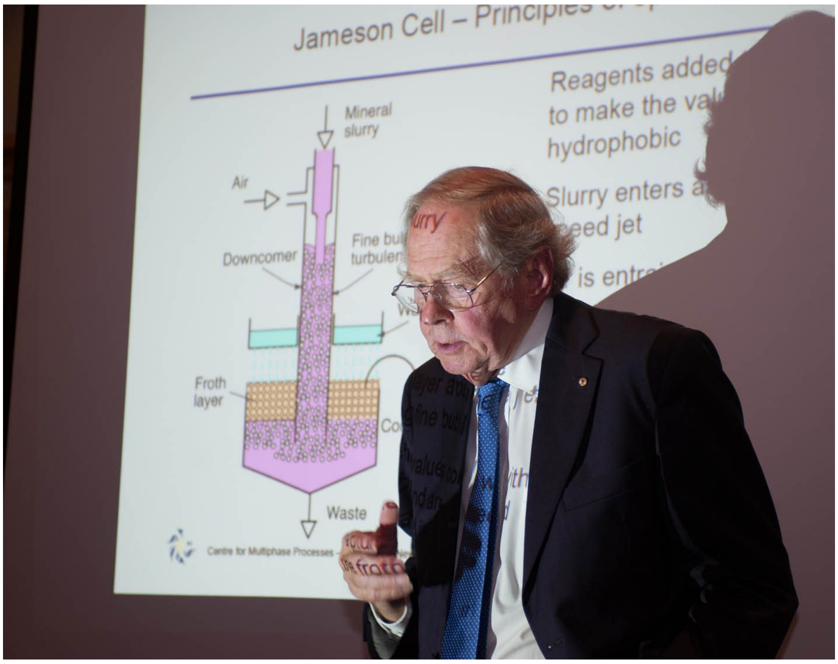
The Jameson Cell

Report of the 1220th OGM

Laureate Professor Graeme Jameson AO

At the 1220th ordinary general meeting of the Society, Laureate Professor Graeme Jameson described the development of the Jameson cell, one of the most important technological contributions to the Australian economy in the last 50 years.

The Jameson cell is a flotation cell used in minerals processing. First two stages of extracting minerals are the mine itself from which the ore is recovered and the concentrator, where the valuable mineral is extracted from the rest. Typically the valuable components are no more than 2% of ore recovered, so there is a massive challenge in isolating this from the ore for further processing. An important technology developed to achieve this concentration step was the flotation cell, a process first developed early in the 20th century.



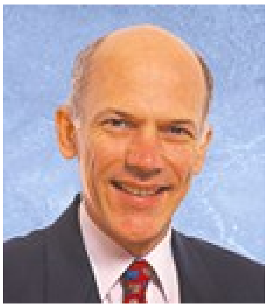
In a flotation technology, the ore is ground up into very fine particles and dispersed with water and surfactants in a large mixing vessel that can be kept agitated and into the bottom of which compressed air can be introduced. Reagents are added to make hydrophobic the valuable mineral particles exposed during the crushing. Air is bubbled through the suspension and the hydrophobic mineral particles attach to the bubbles, float to the surface as a froth and then are skimmed off for further processing and enrichment. Because large volumes of ore have to be treated to recover a relatively small proportion of valuable product, this is a very expensive step in recovering minerals: first, the ore has to be ground to very fine particle sizes (typically around 150 micrometres) – this takes a lot of energy; and second, the volume that has to be treated in preparing the slurry is large, so processing equipment is big and expensive. Any technology that reduces either the cost of grinding or the size of the processing equipment can have a major impact on the cost of production. Professor Jameson's work revolutionised the floatation process by reducing the size of the equipment needed to efficiently float off the minerals.

Over a period of several years, Professor Jamieson identified the optimum parameters for particle size and the corresponding optimum size for the air bubbles used to float the treated particles. Generally, particle size needs to be less than 150 micrometres, or, even better, less than 100 micrometres. The smaller the particle, the more likely it is to consist of the pure mineral. But the real technological breakthrough was identifying that the optimum bubble size is about 300 micrometres. Until then, conventional cells operated using bubbles about three times that size at about 1 mm diameter. Having identified the optimum bubble size, the challenge was then to design equipment that produced the right amount of sheer to generate bubbles of 300 micrometres diameter. This turned out to be relatively simple, using high pressure jets of water to entrain the air.

Much of the commercialisation work was done at Mount Isa in the 1980s and 1990s. Since then, the cell has been deployed around the world and is used routinely to extract coal, copper, lead, zinc and potash and is used in other industries such as oil-sands extraction and industrial waste treatment. The over 300 cells have been installed and the cumulative value created by this invention is more than $25 billion.

Professor Jameson was named NSW Scientist of the Year in 2013.

From the President



April is a busy month. It started with the annual general meeting, followed by a talk by Laureate Professor Graeme Jameson, Professor of Chemical Engineering at the University of Newcastle and NSW Scientist of the Year in 2013. The AGM was well attended and I'm delighted to welcome to new members who were elected to the Council: Judith Wheeldon AM, Erik Aslaksen, Ragbir Bhathal and Marty Cameron. As reported at the AGM, the Society is certainly seems to be a turning point with a great deal of interest being shown in the new Fellowship category, a surge in attendance at meetings and excellent attendances registered for the annual dinner early in May.

The talk given by Professor Jameson was about his work on minerals processing – he invented technologies that have delivered major efficiency advances in minerals processing – was most interesting. The flotation technology developed by Professor Jameson is a world leading innovation and has contributed nearly $30 billion of value to the Australian economy since its first introduction in the late 1980s.

The Society was honoured to have its patron, Her Excellency the Governor, the Hon Professor Marie Bashir, present Distinguished Fellow Peter Doherty AC with his Distinguished Fellowship on Wednesday 16 April. Professor Doherty is the third Nobel Prize winner to be appointed as a Distinguished Fellow of the Society.

On Wednesday 7 May, the Society will hold its annual dinner, awards presentation and Distinguished Fellow's Lecture. The Society's 2013 awards (the Walter Burfitt Prize, the James Cook Medal, the Edgeworth David Medal and the Clarke Medal) will be presented, followed by the 2014 Distinguished Fellows lecture, to be delivered this year by Professor Barry Jones AO Dist FRSN. A number of newly-elected Fellows will be presented with their Fellowship certificates on the evening.

We are very pleased by the rapid uptake of the new Fellow membership category. The Society is seeing the biggest increase in membership for many years. I would like to remind members that if you meet the criteria for Fellowship (as I know many of our members do), please consider upgrading your membership. (The criteria for Fellowship may be found in the Rules and By-Laws – see the link on the Society's homepage.)

If there are any issues you would like to raise with me, I am easily contacted by e-mail at president@royalsoc.org.au and would like to hear from you.

Donald Hector

(Continued from page 1)

want?) Second, who should be responsible for demonstrating new technologies (responsible for progress, experiment, scale up, economic model and "energy equity")? And third, how can we have the best system possible? We must become expert at asking the questions and seeking solutions around the world and, importantly, developing solutions locally where appropriate in order to create a leadership position.

Contact your office bearers

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