



The Bulletin 438

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27 November 2019

For Your Diary:

31 January 2020

Hunter Branch Public Lecture

Prof Ryan Loxton

‘Mathematics in Industry:
Optimisation in Action’

(For more information, see p. 4)

Best Wishes

for the

Festive

Season



Patron of The Royal Society of NSW

Her Excellency The Honourable Margaret

Beazley AO QC

Governor of New South Wales

1279th OGM & Open Lecture

Jak Kelly Award

& Christmas Party

‘All-Integrated Mid-Infrared Laser Sources’

Wednesday 4th December 2019

Gayathri Bharanthan

Department of Physics and Astronomy,

Macquarie University



See page 3 for more information

Date: Wednesday 4th December 2019

Time: 6:00 pm for 6:30 pm

Venue: Gallery Room, State Library of NSW

(Entrance: Shakespeare Place, Sydney)

Dress: Smart Casual

Entry (OGM and Lecture): \$15 for Members, Fellows and Associate Members of the Society, \$5 for full-time Students, \$25 for Non-Members (including a welcome drink)

Christmas Party (buffet style, including drinks): \$55 for Non-Members, \$50 for Fellows, Members and Associate Members, \$25 for students.

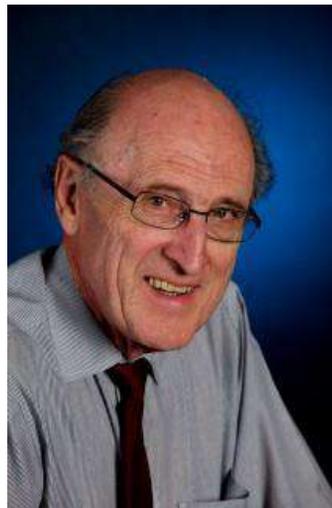
Reservations must be made by Monday 2nd December 9:00am

Reservations: <https://nsw-royalsoc.currinda.com/register/event/64>

Enquiries: royalsoc@royalsoc.org.au Phone: 9431 8691

All are welcome.

From the President



With the Festive Season and end of year approaching, it is a good time to take stock of the year past and the challenges that lie ahead.

There have been some major highlights, including the highly successful first-ever European History of Science Tour; the remarkable Royal Society and Four Academies Forum on ‘Making SPACE for Australia’; the transfer of our Library from storage to the State Library of New South Wales, and the ongoing cataloguing and book repair of the collection; and the success of the ‘Women and Science’ lecture series, jointly with our friends at the Sydney Mechanics’ School of Arts.

But your Council is very aware of the need for improvement. Council wants to see your Royal Society take a much larger role in public policy, and come to be seen as a non-partisan source of expert advice to policy makers. This is already happening to some extent, with an excellent relationship existing with the Office of the Chief Scientist and Engineer, but we are not yet visible enough to policy makers in general. We need to build better relationships with those policy makers, and let them see the extraordinary range of talent and expertise in the Society. Council is also well aware that we need to do more for our Members and Fellows, and many ideas are now being considered by revamped Events and Membership Committees.

Importantly, Council has also decided it needs to greatly improve the gender balance and cultural diversity of the Membership and Fellowship of the Society, and to that end has formulated a ‘Diversity and Inclusion’ policy, about which you will hear much more in the future. For the moment let me encourage all of you to nominate Members and Fellows, and as you do so, to consider especially nominating women and persons from other under-represented groups.

It only remains for me to wish you and your families all the Compliments of the Season, and as they say in the USA, Happy Holidays.

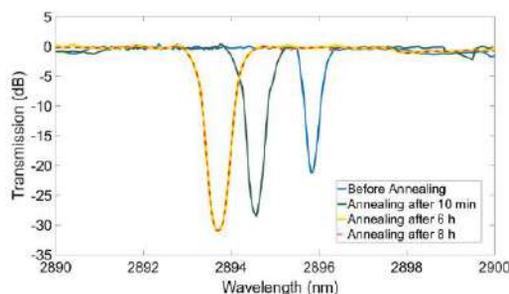
Ian H. Sloan AO FAA FRSN
President
Royal Society of New South Wales
President@royalsoc.org.au

Gayathri Bharathan — Jak Kelly Award Winner 2019

Department of Physics and Astronomy

Macquarie University

‘All-Integrated Mid-Infrared Laser Sources’



Transmission spectra of FBG before and after annealing

The infrared (IR) part of the electromagnetic spectrum is sub-divided into the near (0.8 – 2 μm), mid (2 - 15 μm) and far (15 - 1000 μm) infrared region. Amongst those three, the mid-IR is of particular relevance as it corresponds to photon energies that overlap with the strong vibrational molecular resonances of most common constituents of atmospheric gases and with the liquid water. Potential applications include but are not limited to environmental monitoring, trace molecular detection (e.g., for airport security screening) as well as non-invasive breath analysis where the presence of certain molecules in the human breath can be used as an indicator of a specific disease.

Due to their numerous advantages, fibre lasers represent the ideal light sources for most applications and have therefore become the most widespread type of lasers in the near-IR. In contrast, mid-IR fibre laser technology is still in its infancy, mainly due to the nonexistence of fibre-coupled optical components required to form an all-fibre cavity, which severely limits their applicability. The possibility to utilize femtosecond lasers to directly inscribe high-quality and robust integrated components such as fibre Bragg gratings as well as in-fibre polarizers opens a new avenue for the development of future mid-IR all-fibre laser systems. The aim of my research work is therefore to investigate the fabrication of integrated components in mid-IR compatible glasses for the development of high beam quality all-fibre mid-IR lasers.

Gayathri Bharathan completed her Bachelor's degree in Electronics and Communication Engineering at Mahatma Gandhi University in Kerala, India. This was followed by post-graduate studies in VLSI Design from the Indian Institute of Technology, Madras (IIT Madras). Later, she worked as a lecturer in the Federal Institute of Science and Technology for two years. She then returned to her studies in 2017, relocating to Sydney to pursue a Masters by Research in Photonics at Macquarie University. Her interest in the field of developing lasers for surgical applications led her to continue her studies and she commenced a PhD in March 2018 under the supervision of Dr Alex Fuerbach and Dr Stuart Jackson. At the completion of her PhD, she hopes that she can continue to contribute to the development of new mid-infrared laser sources for practical applications in medicine.

Hunter Branch
Royal Society of New South Wales
Public Lecture
Professor Ryan Loxton
Curtin University of Technology
**‘Mathematics in Industry: Optimisation in Action -
Unlocking Value in the Mining, Energy, and Agriculture
Industries’**



Optimisation is a branch of applied mathematics that focuses on using mathematical techniques to optimise complex systems. Real-world optimisation problems are typically enormous in scale, with hundreds of thousands of inter-related variables and constraints, multiple conflicting objectives, and numerous candidate solutions that can easily exceed the total number of atoms in the solar system, overwhelming even the fastest supercomputers. Mathematical optimisation has numerous applications in business and industry, but there is a big mismatch between the optimisation problems studied in academia (which tend to be highly structured problems) and those encountered in practice (which are non-standard, highly unstructured problems). This lecture gives a non-technical overview of the presenter’s recent experiences in building optimisation models and practical algorithms in the oil and gas, mining and agriculture sectors. Some of this practical work has led to academic journal articles, showing that the gap between industry and academia can be overcome.

Professor Ryan Loxton is the discipline leader for mathematics and statistics in the School of Electrical Engineering, Computing, and Mathematical Sciences at Curtin University. His work focuses on using advanced mathematics to optimise complex processes in a wide range of applications such as mining, oil and gas, agriculture, and industrial process control.

Date and Time: Friday, 31 January 2020, 5-6.30 pm

Location: University House, University of Newcastle's City Campus, Cnr King and Auckland Streets, Newcastle, NSW 2300

Cost: Free

Registration and Further Information:

www.eventbrite.com.au/e/public-lecture-mathematics-in-industry-tickets-83289131033

Report of the 1278th OGM
Wednesday 6th November 2019

Professor Herbert Huppert FRS FRSN
University of Cambridge

‘The Beginning of Weather Forecasting: Matthew Maury, Robert FitzRoy FRS and L.F. Richardson FRS’



Professor Huppert receiving his speaker's medal from Vice-President Judith Wheeldon AM FRSN

The President introduced Professor Herbert Huppert FRS FRSN, Emeritus Professor of Theoretical Geophysics in the Department of Applied Mathematics and Theoretical Physics, University of Cambridge to present the evening's lecture.

Quantitative forecasts, not just that it will be relatively hot in summer and cold in winter, were not introduced until the mid-1800s. How this came about, the individuals whose imagination and hard work made it possible and a short description of the (difficult) physical principles governing the often turbulent motions on many different spatial scales of the atmosphere were summarised.

Our ancestors have often lived with unpredicted changes in the weather, even quite dramatic changes. For social and financial reasons it would be extremely beneficial to have accurate weather forecasts — over land and sea. This was demonstrated graphically by the speaker by referring to specific maritime and other calamities which galvanised the three weather-forecasting pioneers who were the subjects of the lecture. In their own way, each made significant advances in how weather forecasting could occur, with the use of telegraphic communication as a principal element in these advances.

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New Fellows, Members and Associate Member

At the November OGM Fellowships were awarded to Emeritus Professor Christine Alexander, Professor Marcela Bilek, Dr Robert Hewitt, Dr Rachael Kohn AO, Professor John Whitelock and Mr Eddie Woo. Dr Luciano Boschiero and Ms Nyrie Palmer became Members, and one new Associate Member Mr Robert McIntosh was inducted. Congratulations to all!



President Ian Sloan congratulates well-known radio broadcaster on religion and spirituality Dr Rachael Kohn AO FRSN on receiving her Fellowship

Maths teaching superstar Eddie Woo FRSN receives his Fellowship certificate from Professor Sloan



New Member Nyrie Palmer receiving her membership certificate from Professor Ian Sloan

**Report of 21 November 2019
Royal Society of NSW
Southern Highlands Branch**

**Dr Steve Harrison
'Porcelain through History'**



Dr Steve Harrison in his studio

The day before Dr Steve Harrison was to deliver the last lecture of the year to the Royal Society Southern Highlands Branch, the Powerhouse Museum launched its Willoughby Bequest 2020 Commissioning Program. Its media release announced that six artists would work across glass and ceramics to create a new work for the Powerhouse Museum's collection. One of the artists chosen was our speaker, ceramicist Steve Harrison.

In 2017, the Powerhouse Museum received one of its most significant bequests from Barry John Willoughby, a passionate Sydney-based collector of decorative arts. Willoughby bequeathed objects from his private collection along with funds for the acquisition of works by contemporary artists who work with clay or glass. 'The Powerhouse is grateful that this bequest has enabled the Museum to commission new works from six Australian artists working today in his honour,' said Lisa Havilah, Chief Executive, Powerhouse Museum.

Steve Harrison is a local in the Southern Highlands of NSW, living and working in the tiny village of Balmoral. He has only just returned from his most recent trip to China, a destination which he has visited on numerous occasions. To get a better understanding of the essence of porcelain, Steve has stayed and worked in many fundamental sites for porcelain study including China, Korea, Japan and UK. He has brought samples of unique porcelain stones from around the world back to Australia, working to create his own contemporary porcelain pieces from these ancient materials.

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Many of the 87 person audience were intrigued to hear that Steve's doctoral thesis had focused on the natural resources of the Southern Highlands as raw material for studio ceramics. He concluded from this work that the Southern Highlands of NSW is geologically rich in suitable materials for the production of stoneware ceramics, and that there are a few specific *bai tunze* like materials that are very interesting and have considerable aesthetic potential. His research determined that these materials are potentially capable of being developed into clay bodies and glazes of great beauty.

One of Steve's pieces made of Southern Highlands material is shown here. It was woodfired at Balmoral. It is incised 'NRV' and stamped 'LLP', 'SH' and 'crossed pick and shovel' indicating that it was hand-dug. Pots fired in Steve's studio can be recognized because he does not glaze the entire pot, but instead leaves an area around the base so that the clay itself can still be seen.



Steve Harrison, Harrison 82, 1959-2016, ceramic, 6.8cm x 11.7 cm x 12.1 cm

In this lecture, Steve Harrison presented not only many examples of his beautiful ceramic art, but also the detailed chemistry, physics and mathematical algorithms that underpin his processes. He has presented in numerous international conferences throughout Europe and Asia, including the Royal College of Art in London. He has published over 70 research papers and written 6 books, 3 of which have been translated into other languages.

Anne Wood FRSN

Report on the Royal Society of NSW and Four Academies Forum 2019 'Making SPACE for Australia'

On 7th November 2019 the Royal Society of NSW again joined with the Four Learned Academies of Australia to hold the annual Forum, hosted at Government House under the auspices of our patron the Honourable Margaret Beazley AO QC, Governor of NSW. The day was hugely successful, with a record number of women speakers and a wide coverage of the topic from the history of Australia's involvement in Space and our major achievements, to Space law and ethical issues, and finally to Australia's Space economy and potential for further commercialization.

The day was opened by President Ian Sloan, with an excellent address by the Governor, who reminded us that Indigenous people were the first astronomers in the world, using the stars to understand the rhythms of the land and for navigation.



The Honourable Margaret Beazley AO QC addressing the audience at the opening of the Forum

The Keynote address was delivered by Professor Lisa Kewley FAA from ANU, who taught most of us a new word: astroarcheology – the search for planets and early galaxies. Australia has discovered the oldest three stars in the Universe, close to the site of the Big Bang. The most ancient of these is 13.6 million years old. We hope soon to identify the very first star to form after the Big Bang, with the help of our existing telescopes and NASA's new James Webb Space Telescope, to be launched early next year, which will look for the most distant stars and galaxies using infrared waves.

Kerrie Dougherty, well known speaker on Space, gave us a sixty-year history of Australia's involvement in Space research and exploration. She noted that we are entering Space 2.0, with many new startups taking advantage of the latest digital and miniaturization techniques to initiate entrepreneurial activities in Space. Now that we have our own Australian Space Agency – founded last year – Australia will be able to enter into a new age of Space endeavour.

Dr Megan Clark AC FTSE, the Head of the Australian Space Agency, spoke next. She observed that our involvement in Space is part of our current diversification strategy for the Australian economy. We are at the cusp of a transformation from principally Government-based Space expenditure to increasing investment by industry. In addition, Australia will partner with NASA in their Artemis Program: the return to the Moon by 2024. The aim is to have women and men living

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and working on the Moon in order to launch astronauts on a voyage to Mars.

Bill Barrett, from Asia Pacific Aerospace Consultants, argued that we have moved beyond the first two phases of Space development – exploration and experimentation – and are now in the exploitation phase, in which commercial returns become available even though costs are still high. Industry has begun to actively invest and market forces are now driving investment, with the biggest transformation being consumer demand for GPS services, satellite navigation, satellite broadband, earth observation services, etc. The year 1998 was when commercial ventures in Space equalled Government funding for the first time. This century commercial expenditure has skyrocketed, with private enterprise now comprising 80% of global space activity. The Australian Space sector currently generates about \$4 billion per annum in Space products and services, has more than 600 organizations engaged in Space activities, and employs about 10,000 staff in some way. New South Wales is the leader in Space-based employment, particularly in satellite communication, and, of the more than 50 Space startups that have begun in Australia in the last few years, most are in this state. As Australia's first astronaut Dr Paul Scully-Power AM FRAeS observed, the money in Space 2.0 is down here on earth.



A wrapt audience in the beautiful state rooms of Government House where the Forum was hosted

Dr Clark and a number of other speakers highlighted specific areas of Australian expertise that companies should take advantage of to build Australian Space industries, destined to triple by 2030. These include Space situational awareness, robotics and automation, earth observation, laser-based orbital debris tracking and satellite communication. Dr Adam Lewis, Head of National Earth and Marine Observation at Geoscience Australia, pointed out that Australia is leading the world in earth observation using the Open Data Cube Paradigm, invented in 2013 and first employed in this country: traditionally satellites give a view of the Earth in strips, which are then melded together, but this approach does not suit computer analysis. The new paradigm has allowed accurate views of water distribution across Australia over time to monitor the drought and provide information on how many dams contain water, as well as tracking changes in crops, mangrove coverage and other vegetation. It provides Government with evidence for decision

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making, and data for researchers and students. Farmers may subscribe to a service to get detailed information via an app on the status of their paddocks, including the ratio of bare earth to vegetation cover. Internationally, Digital Earth Africa – launched the week before the Forum – will begin tracking water distribution in that continent.

The Governor (centre) with students who attended the Forum. Also present are Dr Susan Pond AM FRSN FTSE FAHMS (second from the left) and Em Prof Roy MacLeod FRSN FSA FAHA FASSA FRHistS (right), who together led the organization of the Forum.



A significant issue in this new era of Space development is the problem of Space junk. Launch costs of getting satellites into Space have gone down dramatically. SpaceX (Space Exploration Technologies Corporation) alone wants to put up 40,000 CubeSats. These miniaturized satellites need very low power, are smart devices and communicate using light. Dr Scully-Power argued that in 5 years time there will be hundreds of thousands of CubeSats in low-earth orbit providing high-resolution images. This contrasts with the 8,000 objects we have launched in the last 62 years. Once objects are in Space they tend to stay there forever: currently we do not have the technology to deal with them. Dr Alice Gorman, a Space archaeologist from Flinders University, noted that, with increasing satellites and Space junk orbiting Earth, they will become more and more visible at night. Within a few decades there will be no-one left alive who has viewed the night sky uncluttered by these objects.

Other ethical issues include the misuse of data collected from Space by criminals or rogue nations, laser blinding of satellites to interfere with transmission, radio frequency and GPS jamming, and even the bombing of satellites. However, Professor Steven Freeland of Western Sydney University reassured us that Space is not a lawless domain: it is governed by international laws and in Australia by our Space Activities Act 1998.

The challenge is to take a holistic approach to Space. Not all objects in Space are junk: Oscar 5, a radio satellite built by University of Melbourne students in 1970, is now a piece of Australian heritage. The Reverend Dr Nikki Coleman of the University of NSW Canberra Space declared that Australia is a world leader in Space ethics. Hopefully, we will be able to deal with these issues and benefit from the new Space industries while maintaining our lasting wonder of Space, its vastness, beauty and mystery.

Dr Laurel Evelyn Dyson, Bulletin Editor

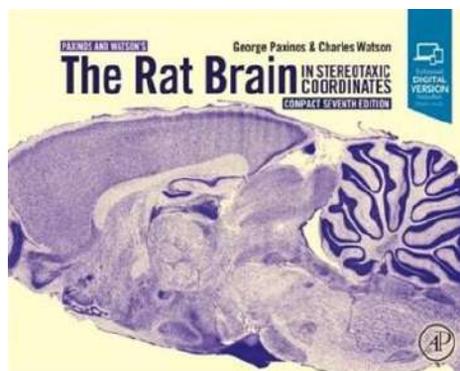
Election of Distinguished Fellow

Professor George Paxinos AO DistFRSN FASSA FAA



The President advised at the November OGM that the Council was delighted to announce the awarding of a Distinguished Fellowship to Professor George Paxinos AO FASSA FAA DistFRSN. This honour is a prestigious award, limited to 25 in number at any time, that recognises internationally-distinguished contributors to science, art, literature, or philosophy.

Professor Paxinos, an eminent Greek-Australian neuroscientist, completed his BA at The University of California at Berkeley, his PhD at McGill University, and then spent a postdoctoral year at Yale University before moving to UNSW, Sydney. He is co-author (with Charles Watson) of *The Rat Brain in Stereotaxic Coordinates*, which, with over 65,000 citations across its seven editions, is the most cited Australian publication and the most cited neuroscience publication. His human brain atlases are the most accurate ones for identification of deep structures and are used in surgical theatres. In community impact, his 2018 discovery of the human endorestitiform nucleus reached 412 million people across 70 countries. Professor Paxinos is credited with two paradigm shifts in his field of neuroscience. First, during a sabbatical at Cambridge in 1977, he learned immunohistochemistry and applied it for the first time in brain atlases. Secondly, in his avian brain atlas, he used neuromeric criteria to delineate the entire brain for the first time.



The recipient of many honours and prizes around the world, Professor Paxinos is an Officer in the General Division of the Order of Australia (2002). He was awarded the Royal Society of New South Wales Walter Burfitt Prize in 1992 and was elected to Fellowship (FRSN) in 2014.



A Great Christmas Present: Society Membership

The perfect gift for curious minds!

Empower your friend or relative to join us at
The Royal Society of NSW
 The Society of Ideas

RSNSW Coming Events

Date	Event	Speakers	Topics and Presentations	Location
4-Dec-19	Ordinary General Meeting	Jak Kelly Award Winner	2019 Jak Kelly Award Presentation & Christmas Party	State Library of NSW
31-Jan-2020	Hunter Branch Public Lecture	Prof Ryan Loxton	Mathematics in Industry: Optimisation in Action	University House, Newcastle

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