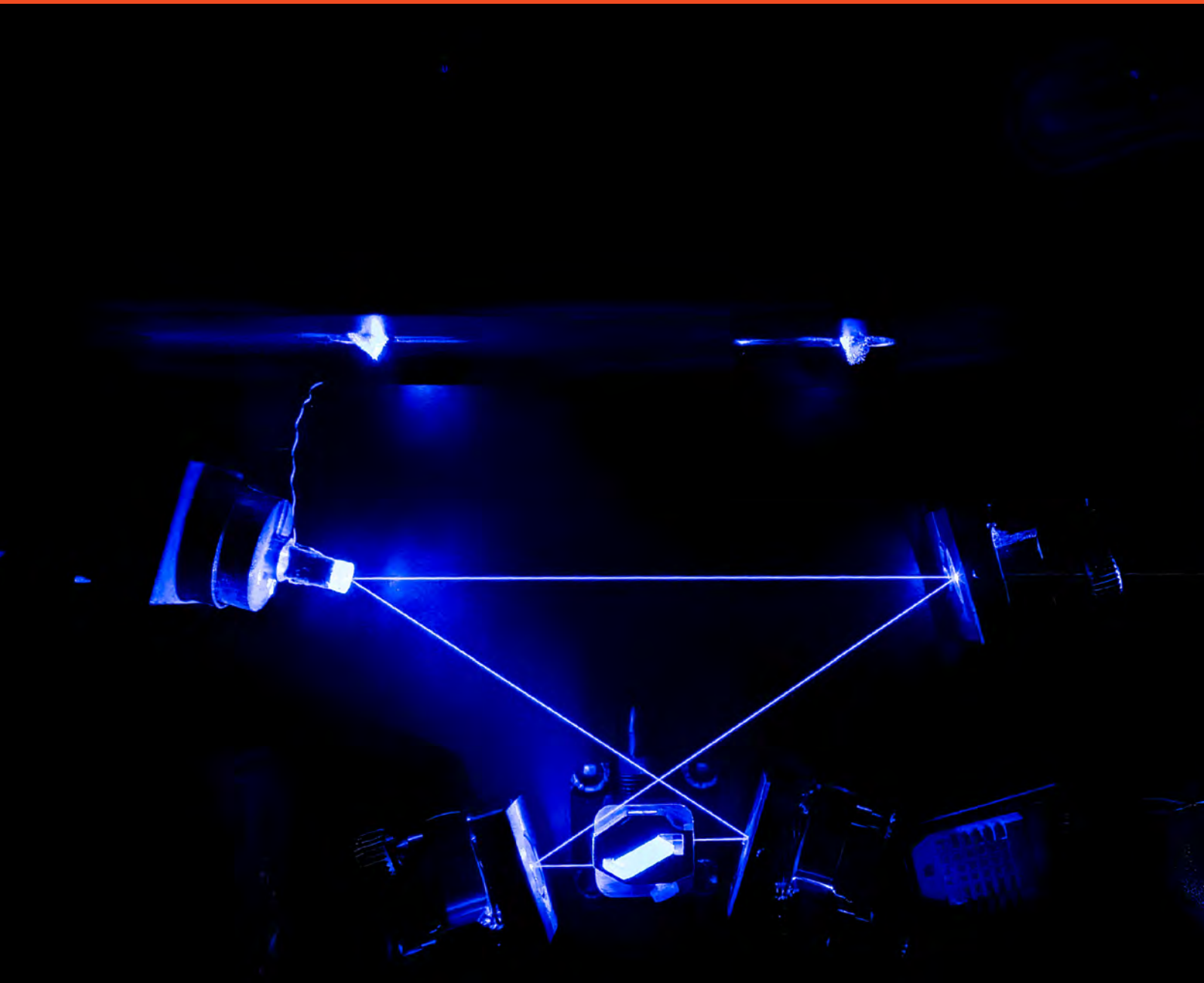
THE UNIVERSITY OF SYDNEY

The University of Sydney Physics Foundation

Annual Report 2023



We recognise and pay respect to the Elders and communities – past, present, and emerging – of the lands that the University of Sydney's campuses stand on. For thousands of years they have shared and exchanged knowledges across innumerable generations for the benefit of all.

Cover image credit: Jayne Ion

Cover image description: Cavity-enhanced generation of 235nm ultraviolet laser light in the Quantum Control Laboratory's Penning ion trap. The experiment explores using lasers to manipulate individual, ultra-cold trapped ions for quantum-enhanced sensing applications and simulations of quantum many-body physics that are intractable with conventional computers.

The University of Sydney Physics Foundation
Annual Report 2023

Contents

“A life lived in the pursuit of excellence – is a life well lived”

Professor Harry Messel AC CBE

Presidents Report
Michael Winternitz

A triumphant return to an in person Professor Harry Messel International Science School attracted over one hundred of the top high school science students from around the world to the University of Sydney.

During this prestigious, world renowned event, ISS scholars were challenged by world leading academics in two weeks of intensive lectures, laboratory and social engagements.

The return to an in person ISS, following two pandemic-related online versions was a timely reminder of the impact the ISS has on young students. The experience of traveling to Sydney, being honored, and made to feel like they matter, and that they are special and will have an impact upon society will no doubt shape their lives, as the ISS has done for so many previous scholars.

The caliber of the ISS scholars was once again outstanding, and the opportunity of meeting scholars at the ISS Gala Evening was an absolute honor for myself and indeed other Physics Foundation members.

What was even more touching was to understand some of their backgrounds and learn how competitive it was to be selected to represent their country at the ISS.

All of this makes one pause and consider the fact that the ISS continues to be one of our proudest, most successful and indeed enduring initiatives of the Physics Foundation.

The Grand Challenges have been an immensely successful initiative over the past five years, that have encouraged innovation, excellence and interdisciplinary research, within the School of Physics and indeed the wider University. The Physics Foundation is very proud to have provided over two million dollars worth of prizes for these outstanding research projects.

The Physics Foundation continued its support of numerous School Prizes, awarded for academic excellence which is a core value that underpins the Physics Foundations objective of supporting education within the School.

Of particular note, the Physics Foundation celebrates our 70th anniversary in 2024, as the first Foundation of its kind in the British Commonwealth, and one of the most successful within the University of Sydney.

This anniversary is a timely reminder to reflect upon our incredible history and success in supporting the School of Physics and promoting excellence, science and education in the wider community.

Well over $100 million has been raised by the Physics Foundation, supporting the School and wider scientific endeavors. It has enabled and I am pleased to say continues to contribute to numerous scientific advancements.

I would like thank Head of School Professor Tara Murphy, our donors, supporters, and indeed past and present Physics Foundation council members for their support in what has been a very eventful year.

We have in front of us, what will be no doubt an exciting future for both the School of Physics and the Physics Foundation, as we work together to promote excellence, education and promote scientific endeavors.

Michael Winternitz

Physics Foundation President

Physics Foundation
Objectives and Aims

The pursuit of excellence is at the heart of our mission.

For over 50 years, the Foundation's philanthropic work in supporting scientific research, education and outreach has continued, thanks to support from science, business, industry and government.

The University of Sydney Physics Foundation, established in 1954 by Emeritus Professor Harry Messel AC CBE, was the first Foundation established within the University of Sydney and the first of its kind within the British Commonwealth.

The Foundation was to support the School of Physics as a voluntary philanthropic association of individuals and private organisations dedicated to the pursuit of excellence in science education, research, training and communication. Today, the Foundation still carries out this important role.

Aims of Foundation

To support the School of Physics and to generate philanthropy, promote careers and broaden knowledge and understanding of science (in particular physics) in the wider community.

Objectives of Foundation

- To increase the resources of the University (by fundraising or by otherwise securing gifts and grants or by securing the provision of services or other non-financial contributions).
- To assist the Senate and the Vice-Chancellor in the promotion of the field of physics, through the School of Physics and to cooperate with the School of Physics, the Faculty of Science and the University in promoting the significance of science and developing an understanding of its importance both within Australia and internationally.

Foundation Activities in Support of its Objectives

- Raising funds from fees, donations, bequests and sponsorships.
- Building a strong financial position to ensure the Foundation can continue to meet its objectives in the long term.
- Providing additional funding to support the work of the School of Physics, through its scholarships, the purchase of equipment, and the underwriting of other initiatives.
- Promoting seminars, courses and workshops in the field of physics.
- Inspiring senior secondary school students through the Professor Harry Messel International Science School (ISS) to continue studies in science, and physics in particular, and to take up science careers.
- Any other initiatives and activities as the Foundation determines appropriate.

The Messel Endowment
Donations to the Foundation

The Messel Endowment

The Physics Foundation established the Messel Endowment in 1999 to ensure the Professor Harry Messel International Science School (ISS) continues in perpetuity.

Currently there are over 200 supporters to the Messel Endowment. The two largest donors to date have each donated over $1 million. These donors are classed as Extra Galactic Donors and are:

- ·Australian Government through the then Department of Industry.
- ·Mr Lee Ming Tee, through Mulpha Australia.

As of the 31st of December 2023, the Endowment holds $7,696.706 in funds. During 2023, donations and bequests to the Foundation totalled around $17,000.

The Physics Foundation is appreciative of all our donors to the Messel Endowment.

Without this valued support the ISS could not continue its important work of honouring excellence in outstanding Year 11 and 12 science students from Australia, China, India, Japan, New Zealand, Singapore,Thailand, the UK and the USA and encouraging them to pursue careers in science.

The Endowment seeks to accrue further funds through gifts, grants and bequests to ensure the ISS can be run in perpetuity with due allowance for inflation over the years.

Donations of $2 dollars and over are tax-deductible. Pledged gifts (donations spread over a three-to-five-year period) are welcome and are also tax-deductible.

Careers and Achievements

The ISS now has over 5000 alumni with many going on to outstanding career achievements in their chosen fields including science, medicine, engineering and technology.

Please help us in continuing to offer this world-class program to these talented students who come from diverse cultures and backgrounds.

Donations to the Messel Endowment can be made online, or via mail. A donation to the Messel Endowment is an investment in the future of science. For more information go to the Physics Foundation website at [Physics Foundation - Faculty of Science (sydney.edu.au)]

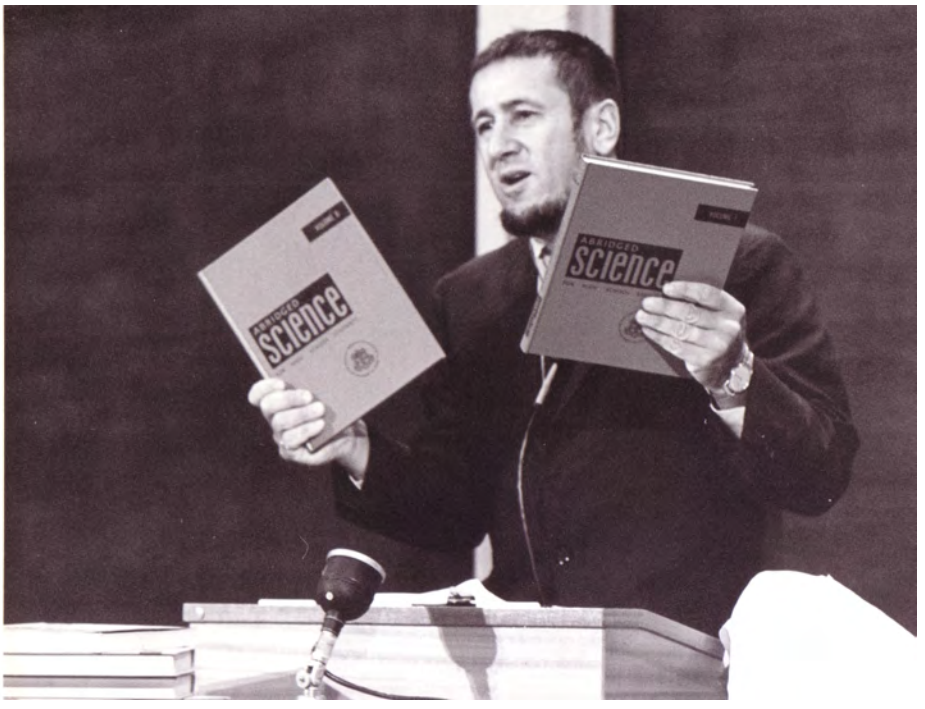


Image: Professor Harry Messel with Science Textbook, 1965. The University of Sydney Archives.

The University of Sydney Physics Foundation
Members 2023

Foundation Staff

- Professor Tara Murphy, Head, School of Physics
- Sian Edwards, Administrative Officer

Patron

- Her Excellency the Hon. Margaret Beazley AC QC

Past Presidents

(initial year of presidency shown)

- Dr Richard GC Parry-Okeden (1954)
- Sir James N Kirby CBE (1957)
- Sir Frank Packer KBE (1960)
- Sir Noel Foley CBE (1963)
- Sir Walter Leonard DFC (1966)
- Sir Robert Norman (1969)
- Mr James A Macpherson (1972)
- Sir Walter Leonard DFC (1973)
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- Mr Graham Hall (1999)
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- Mr Trevor Danos AM FTSE (2008)
- Mr Jim O'Connor (2011)
- Mr Albert Wong AM (2013)
- Emeritus Professor Anne Green AC FTSE, FRSN, FAIP, FASA (2017)

Past Directors

(initial year of directorship shown)

- Emeritus Professor Harry Messel AC CBE (1954)
- Emeritus Professor Max Brennan AO FAA (1987)
- Professor Lawrence Cram AM (1991)
- Emeritus Professor Richard Collins FTSE (1997)
- Professor Bernard Pailthorpe (2002)
- Associate Professor Robert Hewitt (2003)
- Emeritus Professor Anne Green AC FTSE FRSN FAIP FASA (2006)
- Professor Clive Baldock (2010)
- Professor Tim Bedding FAA (2012)
- Professor Celine Boehm (2018)

Foundation Council 2023

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- Mr James R Kirby, Deputy President

University Officer

- Professor Marcel Dinger PhD, GAICD, FFSc (RCPA) (Research), FRSN

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- Professor Gemma Figtree AM FRACP FCSANZ FAHA
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- Professor Greg McRae
- Mr James Read
- Mr Michael Winternitz

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- Ms Alexia Nicholson

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Founder

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- Associate Professor Robert Hewitt
- Dr David Mills AM
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- Mr James R Kirby
- Professor Greg McRae
- Mr James Read
- Mr Michael Winternitz

Corporate Members

- The James N. Kirby Foundation
- The Nell and Hermon Slade Trust

Head of School Report
Professor Tara Murphy

As I write this report, we are preparing to celebrate the 100th anniversary of the School of Physics building, and the 70th anniversary of the Physics Foundation. In 1924 the Sydney Morning Herald proclaimed, "Sydney University is to have what will be the finest school of physics in Australia, and perhaps, in the Southern Hemisphere."

Today there is no doubt the Physics building is still one of the most impressive pieces of architecture on campus. It is inspiring to work in a building in which many thousands of students have received their education (although current staff will tell you there are some disadvantages of working in a heritage-listed building when it comes to repairs and maintenance!).

I have been reflecting on how much has changed in Australian society, and in the higher education section since this critical period in our history. Many aspects of the modern University and our School would be unrecognisable to those scholars of the early 20th Century. However, one thing that remains the same is our commitment to world-class research and teaching.

It is not possible to overstate the impact the Foundation has had on the School of Physics over this period. Our histories are woven together. As the first Australian philanthropic foundation for the support of scientific research and education, the Foundation enabled a rapid expansion of the research activities and international profile of the School from 1954, putting an end to the days in which physics at Sydney was led by a single professor. The Foundation has initiated and supported many high impact programs from the long-standing International Science School through to the more recent Physics Grand Challenges.

I am excited that this month we are launching the newest of these major initiatives, the Physics Foundation Scholarship scheme. The School of Physics prides itself on the outstanding educational experience we provide for our postgraduate research students. Our training in independent scientific research sets our students up for careers at the forefront of research, and as pioneers in industry and innovation.

We anticipate the scheme will attract some of the best students from Australia and around the world to undertake a PhD at the University of Sydney. By providing a full stipend, it will allow them to focus on their research careers and enable students to pursue their studies regardless of their background or current financial circumstances. The scheme will also provide a modest research budget to enable students to communicate their results at national and international conferences.

The new scholars will strengthen the research environment in the School and receive world class scientific training. Over their careers, these future leaders will have a major impact on science and society and strengthen the international profile and networks of the School and the Foundation. We expect our first students to start later in 2024.

This scheme, along with some critical hiring we are doing in both research and education-focused roles, is bringing a feeling of renewal and positive energy to the School. I look forward to working with the Foundation in the coming year as we get this and other initiatives underway.

Professor Tara Murphy

Head of School of Physics

School of Physics
Prize Night

The School of Physics Prize night celebrates outstanding students at the School of Physics. The Physics Foundation supports a number of awards, which reflects one of our core objectives of supporting and promoting excellence and education within the School.

The School of Physics Prize Night was held on the 14th of September to celebrate the achievements of outstanding physics students.

The Physics Foundation has a proud history of supporting numerous awards, and President Mr Michael Winternitz attended the award ceremony to present certificates to several outstanding students, alongside Head of School Professor Tara Murphy.

The occasional address was made by Dr Vanessa Moss, who is a radio astronomer based at CSIRO, Australia's national science agency, working at the boundaries between astronomy, telescope operations and data science. She is also a School of Physics alumni and shared her story, inspiring students on the possibilities for their future careers in science.

Physics Foundation Sponsored Awards

The University of Sydney Physics Foundation Scholarship No I - Awarded to students Ramond Trinh, Sophie Fletcher, Daniel Bruwel, Maxwell Boyle and Thomas Schmaltz for proficiency in First-year Physics.

Science Foundation for Physics Scholarship No II - Awarded to students Rhys Mackintosh, Alexander Lin, Andrew Li, Vanathy Arudselvan, Amelie Skelton and Nash Hawkins for proficiency in Second-year Physics.

The University of Sydney Physics Foundation Scholarship No III - Awarded to students Elden Loomes, Nikita Nikultsev, Linda Losurdo, Mali Land-Strykowski and Eben Taylor for proficiency in Third-year Physics.

Physics Foundation Prize IV – Awarded to students Thomas Schmaltz and Sameer Khan based on overall performance in group work in PHYS1003/PHYS1004.

Physics Foundation Prize V – Awarded to students Murray Jones, Yunki Yau, Adrian Wong, Riley Fitzgerald and Riley Jones based on overall performance in group work in PHYS1902.

Physics Foundation Prize VI – Awarded to students Lauren Ashby, Linda Losurdo and Sepehr Saryazdi based on overrall performance in group work in PHYS3888.

Image: Mr Michael Winternitz and First-year winner Sophie Fletcher.

Physics Foundation Grand Challenges
2023 Round

Physics Grand Challenges 2023

The Physics Grand Challenges were established by the Physics Foundation in 2019 as part of a special five year initiative, with the aim of supporting unconventional, innovative, interdisciplinary research projects that would typically struggle to attract conventional funding sources.

A live pitch event was held on 16th November, where four project leads pitched their projects to a selection panel in front of a live audience. Each lead had 10 minutes to present followed by a 5-minute Q&A with the Panel.

The 2023 selection panel included:

- Emeritus Professor Lawrence Cram AM
- Professor Les Field AM FAA
- Professor Anita Ho-Baillie

2023 Winners

Associate Professor Boris Kuhlmey – Nanostructured Textiles for A Sustainable Warming World – Awarded $250,000 over two years

Limiting climate change and adapting to warmer conditions are undeniably this century's greatest challenge. The world needs to reduce its energy consumption, yet air-conditioning already accounts for 10% of global energy, and is the fastest growing use of energy in buildings. With increasing parts of the world becoming inhospitably hot, and some parts predicted to even become uninhabitable soon, effective cooling is shifting from a comfort to a vital necessity. The conflicting need for increased cooling while lowering energy consumption requires an entirely new approach.

The team aims to develop new types of textiles that can keep people cool in hot environments, without using any energy or electricity. These textiles are based on a technique called passive cooling, which means they can reflect the sun's heat and radiate the body's heat into the cold of space. This way, the textiles can lower the temperature of the wearer by several degrees, even in full sun. Emphasis will be on using materials suitable for everyday wear already use in the textile industry, changing their properties through nanostructuring.

Dr Sahand Mahmoodian – Quantum many-body techniques for machine learning – Awarded $50,000

This project combines two incredibly important and exciting topics in modern science: quantum physics and machine learning, for the analysis of time-dependent signals.

Time dependent signals are ubiquitous and are central to solving problems in industries as diverse as biomedicine, mining, social media, and finance.

The project brings together world-leading expertise in quantum many-body physics, time-series machine learning, and neural networks to develop cutting-edge time-series classification methods that leverage powerful techniques from quantum mechanics for the first time.

Associate Professor Stefano Palomba – Optical Nose: A Revolution in Mobile Sensing – Awarded $50,000

The Holy Grail in molecular sensing, is the capability to detect and identify any individual molecule in a mixture, like pollutants in air (CO2, CH4) or water (hydrocarbons, nitrides), biomarkers for diseases in body fluids (DNA, exosomes), very small pathogens in air/breath (coronaviruses, influenza). Raman scattering is the ideal physical phenomenon for the detection and identification of individual molecules. However, it is very difficult to harness due to its low efficiency. Hence, it needs to be enhanced.

What is needed is a chip-based enhanced Raman scattering scanner that continuously detects and identifies an arbitrary passing molecule or ensemble of molecules (corresponding to an odour or scent). This device would act like the olfactory system of humans or animals but based on Raman scattering.

We envision to develop such a scanner in the form of an on-chip enhanced Raman scattering sensor, thereby realising an "artificial optical nose". Particularly, in this proposal, we will focus on specific biomarkers for early pancreatic cancer detection, as our primary "killer application". The vision is to increase the survival rate by detecting these biomarkers and therefore detecting the presence of pancreatic cancer early enough to be more effectively treated.

Image: Physics Grand Challenges 2023 Winners. Left to Right: Mr Michael Winternitz (Physics Foundation President), Joshua Moore (Research Associate - Quantum many-body techniques for machine learning), Associate Professor Stefano Palomba, Associate Professor Boris Kuhlmey.

Physics Grand Challenges 2021 Update

Eye in the Sky: Remote Sensing for Advanced Ecosystem Monitoring

Aim and Background

This project was developed in response to the devastating bushfires of 2019/2020. It aimed at improving the monitoring and management of ecosystems through remote sensing.

In particular, we planned to develop two sensor technologies, capable of being deployed on remote sensing platforms. The first is a compact and affordable hyperspectral imaging system made from off-the-shelf components ('Open HSI') and the second is a novel gas sensor, to enable the detection of greenhouse gasses and gases associated with combustion and plant stress.

In the later stages of the project we will integrate these new data streams with full-cycle chemical accounting and relate these findings back to ecosystem health indices, and use this data to identify particular areas where actions can be taken. We call this concept 'precision conservation', analogous to 'precision agriculture'.

We have partnered with Bush Heritage Australia, and use their reserves for field work in the later stages of the project.

Progress and Achievement

Progress to date has focussed on the sensor development. The Open HSI sensor (pictured) has been completed and published. Software and other resources for the sensor have been made publicly available on github github.com/openhsi. In contrast to multispectral sensors – which only sample specific regions of the spectrum, the Open HSI sensor as currently configured allows the data to be collected across the full visible spectrum.

In the next stage of development, we will mount the sensor on a drone to get data from the field. Initially this will be a University-owned site, but when we are confident that the sensor and integration with the drone is optimized, we will use it on a site of interest in the context of bushfires.

The novel gas sensor has also been demonstrated in the lab, and a publication has been submitted. Most optical sensors use a single absorption feature to identify gases. By contrast, this sensor uses a bespoke fibre grating, fabricated at the University, to precisely mimic the many spectral features of a target gas, improving sensitivity and reducing the false positives from similar gases.

The sensor has now been patented, and we have been awarded a grant from the University Commercialisation Office to test for other industrial applications. We have also partnered with the Food Agility CRC for a NSW Government Clean Tech grant. If successful, we would use the sensors to monitor methane production in livestock.

Image: Open HSI Sensor

While the sensor has been demonstrated in the lab, more work is needed to reduce the size, test the capacity to work in ambient conditions (without an external light source), improve performance and enable it to be successfully used on a drone.

Student Engagement

Two third year students did a project (Maria Nicolae and Katherine Kennedy) on using multispectral imaging to determine the health and extent of seagrass meadows. The figure to the right shows the drone scan for a sea grass meadow (image credit: Maria Nicolae).

PhD student Matthew Rahame demonstrated the novel fibre optic sensor, and PhD Yiwei Mao demonstrated and published the Open HSI sensor. Additionally, we have partnered with a team of Engineering PhD students who will use the Open HSI sensor together with a novel edge computing system on a drone. This system will use improved processing and algorithms to do much of the image processing on the drone itself- greatly improving efficiency. It will be tested in 2024 on a site on the Great Barrier Reef, and we hope to use it later Bush Heritage sites.

Given the lengthy visa delays in appointing a post-doctoral fellow, we are currently exploring the possibility of converting the post-doctoral position to a PhD studentship.

Associate Professor Maryanne Large

Project lead

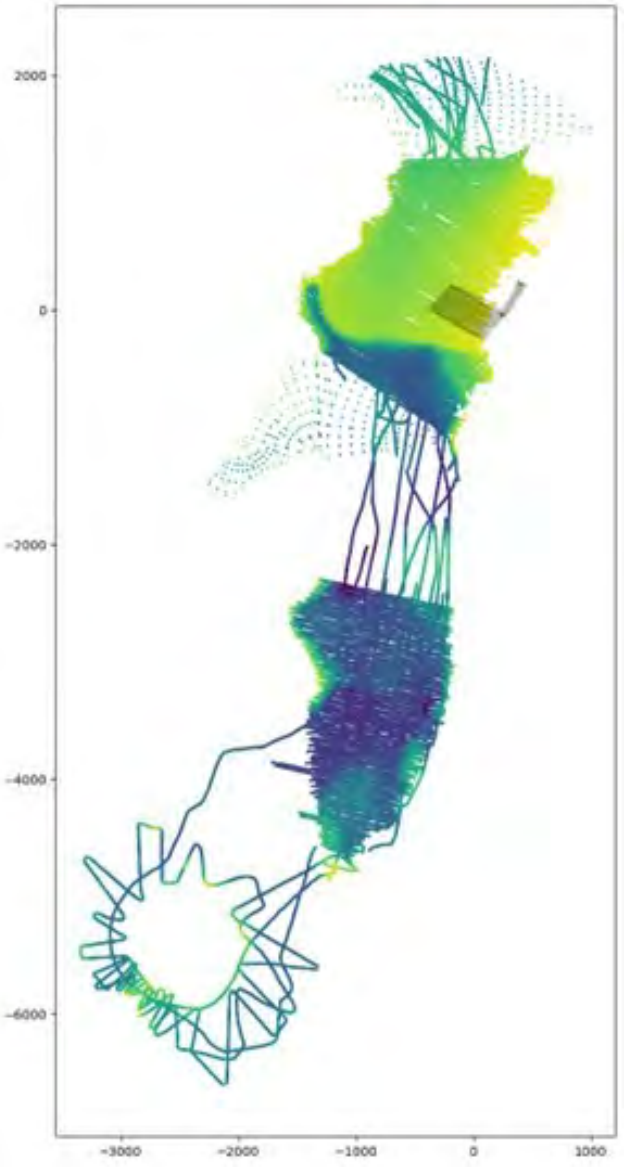


Image: Drone Scan for a sea grass meadow, Maria Nicolae

Physics Grand Challenges 2021 Update

Modeling the development of biological structures using next generation bioscaffolds

Aim and Background

This project aims to develop novel approaches to tissue regeneration using next generation 3D bioscaffolds to mimic the structure and function of blood vessels.

Disease of the heart and blood vessels, collectively known as cardiovascular disease, accounts for the leading cause of death worldwide. Inflammation, dysfunction of vascular cells, and dysregulation of the immune cells at the interface of the blood vessel wall, can lead to thickening and narrowing of blood vessels, ultimately leading to the obstruction of blood and tissue damage.

Currently, treatment options for cardiovascular diseases remain limited, and there is high reliance on lifestyle modifications, pharmacological intervention, and surgical intervention (known as bypass surgery).

In the case of bypass surgery, either autologous (from the patient) or synthetic (made in the lab) grafts can be used as an intervention; however, autologously sourced tissue is limited in its supply, and currently available synthetic grafts are limited by their biomechanical properties (e.g., stiffness, hydrophobicity, and biodegradability) for smaller vessels. Herein highlights an important unmet clinical need.

This project brings together expertise from The School of Physics on the fabrication of microstructures in bioresorbable materials and on the plasma functionalisation of their surfaces. Together with expertise in the field of stem cell biology from The School of Medical Sciences, the project aims to differentiate stem cells to cells of the vascular wall using plasma-treated, growth factor-coupled polycaprolactone grafts as a potential treatment option for patients with small vessel cardiovascular disease.

Progress and Achievement

In 2023, the project has been able to get properly underway as we have recruited Rachel Shparberg, a postdoc with highly relevant experience and skills. She has quickly taken over the work in progress and has focused on vascular differentiation.

We have developed and are in the process of testing these protocols on mouse and human embryonic stem cells, including optimising growth factor combinations, plasma treatment, cell culture, cell characterisation, and processing methods.

To date, we have been able to show that select growth factors, when immobilised to plasma-treated, polycaprolactone discs, are able to promote the differentiation of mouse embryonic stem cells into vascular smooth muscle or endothelial cells.

The next stage is to assess whether we can do this using human embryonic stem cells, and importantly, whether we can co-culture vascular smooth muscle cells and endothelial cells together.

We are also investigating methods to improve the architecture of the graft to enhance cell attachment, growth, and differentiation.

In addition to ongoing lab work, we have since had the proof-of-concept work accepted for publication in Engineered Regeneration. Also, a record of invention has been submitted to the Commercialisation Office and is under consideration.

There have been several discussions with potential funding partners to take this work to the next level. This includes involvement in a proposed new CRC.

Endothelial cells

Vascular smooth muscle cells

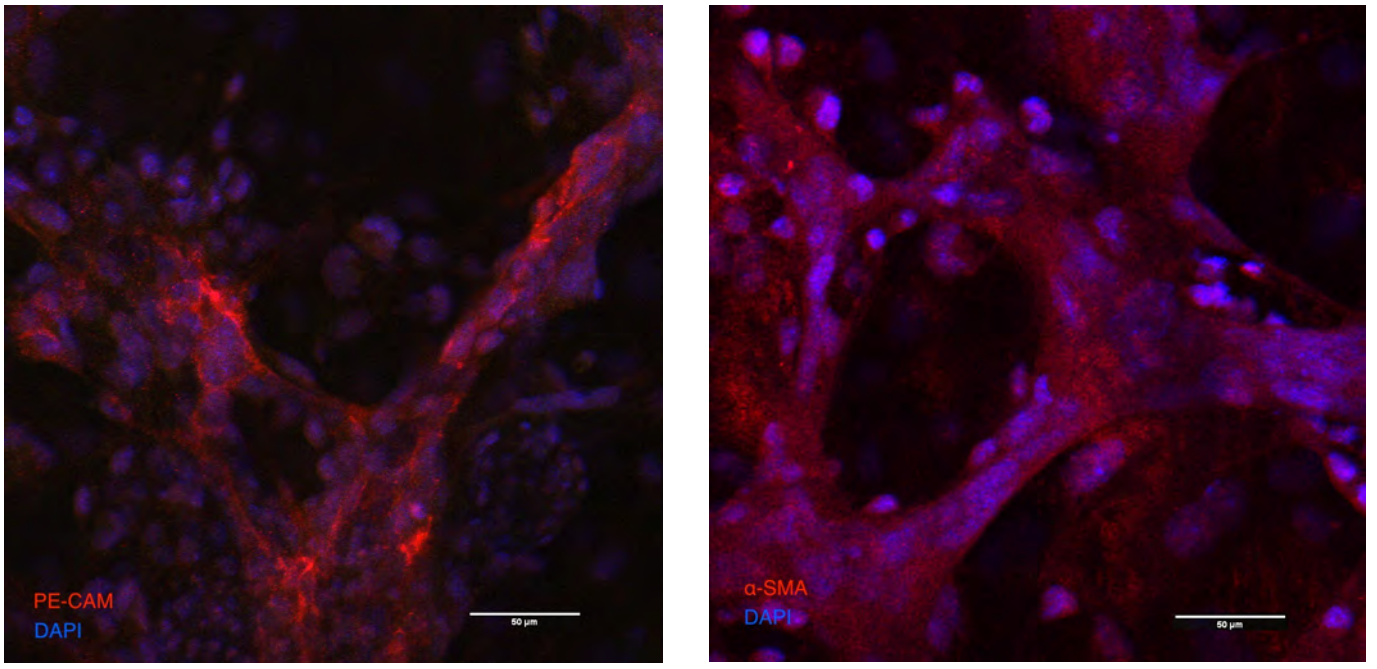


Figure 1. Differentiation of mouse embryonic stem cells into cells of the blood vessel wall on plasma-treated, growth factor-coupled polycaprolactone discs.

Student Engagement

Max Jotsons, a Biomedical Engineering Honours student worked on this project in 2023. Max focused on two aspects of building a blood vessel.

Firstly, he demonstrated preliminary data showing the generation of vascular smooth muscle cells. The next aim was to begin 'building' a blood vessel by growing different types of cells together as they would appear in the body.

Max developed methods to co-culture mouse embryonic stem cell-derived vascular smooth muscle cells and endothelial cells together.

Dr Rachel Shparberg

Postdoctoral Research Associate

Physics Grand Challenges 2022 Update
X-ray Imaging Based on Metal Halide Perovskites

Aim and Background

X-ray imaging has wide applications in medical imaging, non-destructive inspection, and scientific research. As shown in Figure 1, X-rays with different photon energies have different penetration powers and thus have different applications. In particular, X-rays with the energy of 25–40 keV are employed for mammography, and X-ray photons with energies of 40–130 keV are used for radiography and computed tomography (CT), such as for the diagnosis of COVID-19. It is well recognised that higher levels of accumulated radiation exposure are associated with an increase in cancer risk.

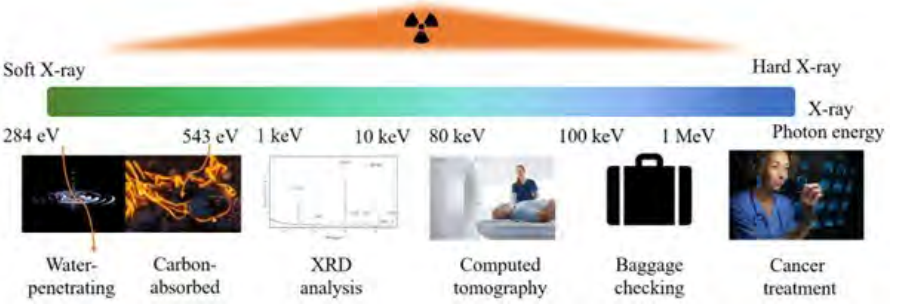


Figure 1. Classification of X-rays and the related application based on their energy.

This project aims to develop new X-imaging devices with higher sensitivity, high resolution, and lower X-ray doses.

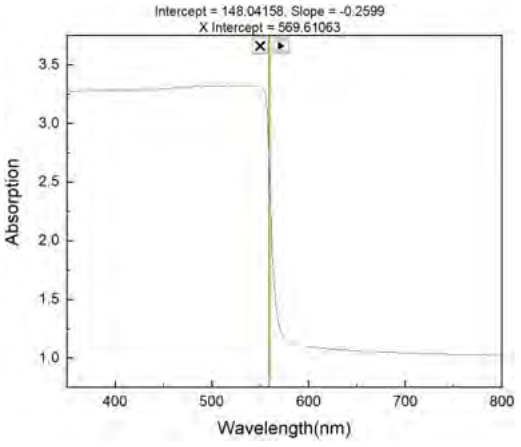
Traditional materials for X-ray detectors, such as cadmium tungstate (CdWO4),α-Se, and mercury iodide (HgI2), have their limitations due to complex synthesis and unsatisfactory performances. Recently, metal halide perovskites as excellent photosensitive materials have attracted considerable attention in various energy and optoelectronic applications, including photovoltaic cells, photodetectors, light-emitting diodes, and lasers. More importantly, this family of materials demonstrates a relatively high atomic number, large charge mobility-lifetime (μτ) product, moderate density, and tuneable bandgaps with some of the properties even superior to state-of-the-art conventional materials. Therefore, halide perovskite X-ray detectors hold great promise to realize high-performance, low-cost practical imaging applications.

Progress and Achievement

We have successfully fabricated integrated halide perovskite single-crystal films on the FTO substrates with a surface area of up to 6×6 cm, as shown in Figure 2(a). The sharp peaks from XRD also demonstrate the excellent crystallinity of the obtained MAPbBr3 perovskite single-crystal films in Figure 2(b). Figure 2(c) indicates an obvious absorption at 570 nm which is consistent with the characteristic of MAPbBr3. From Figure 2(d), the space-charge-limited current (SCLC) was measured to determine the trap density and carrier mobility, which are calculated as 1.3×10^10 ⟦cm⟧^(-3) and 56.91⟦cm⟧^2 V^(-1) s^(-1), respectively from VTFL=1.2V. The results of these integrated single-crystal films are clearly better than those of polycrystalline thin films and comparable to those of pure single crystals. Moreover, with this integrated design, we also achieved a large surface area, which is a major challenge for single crystals. Meanwhile, SEM results in Figure 2(e-f) present the surface morphology and the elemental composition and distribution of MAPbBr3 single-crystal films, respectively.

Our progress was negatively impacted by the ongoing renovation of our laboratory. The good news is that the renovation will be finally completed in coming months. Then we can expedite our progress.

(a) Integrated single crystal film on FTO substrate.



(c) Absorption test from 350 nm to 800 nm with a bandgap corresponding to 570 nm.

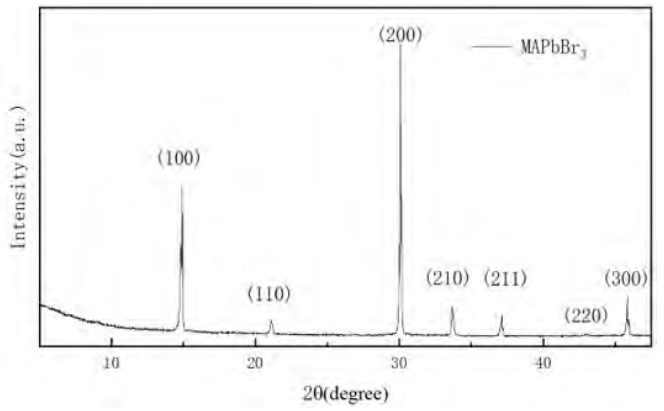
Student Engagement

We have recruited a PhD student, Mr Runkai Liu, for this project in early 2023. He has successfully passed the PEM and submitted a review manuscript to Matter – a top journal in this field. He mastered relevant experimental skills from synthesis to XRD, SEM, RPF, and absorption spectroscopy. More importantly, he has achieved the above mentioned promising results and had a plan in place to further improve the perovskite films.

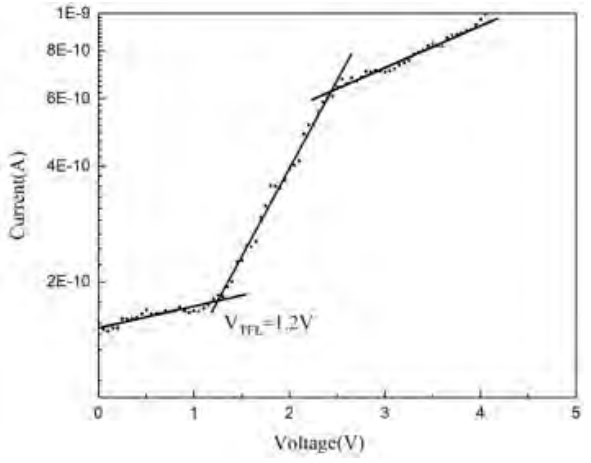
In addition, two existing PhD students, Ms Fang Zeng and Mr Taoyuze Lv, who specialised in perovskite solar cells and DFT calculations, are also engaged in this project and contributing to this project by using their own skills.

Professor Rongkun Zheng

Project Lead

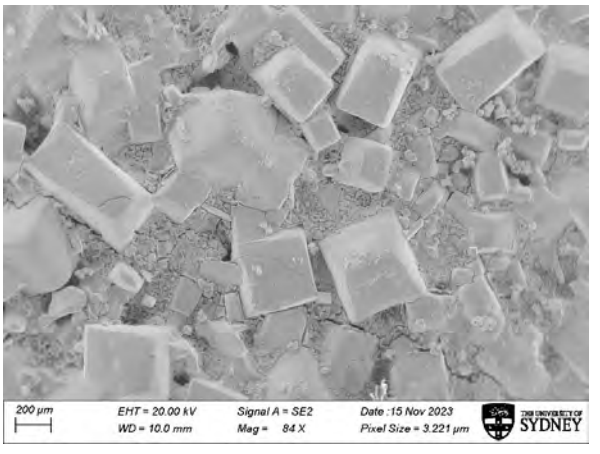


(b) XRD analysis for MAPbBr3single crystal.

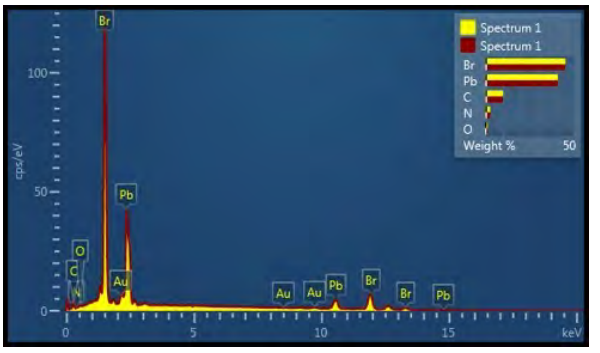


(d) Electrical characterization for trap density and carrier mobility by SCLC.

(e)



(f)



(e-f) SEM and EDS for surface morphology and elemental identification for MAPbBr3 sample.

Physics Grand Challenges 2022 Update
Universal Neurophotonic Interface: Bionics with "Feeling"

Aim and Background

Everyday actions such as grabbing an object, walking, admiring a view, and enjoying music are impossible for millions of people who suffer from a nerve injury or the absence of a limb/organ.

Limbs, eyes, ears, and organs are all connected to the peripheral nervous system (PNS), receiving commands from the brain and returning sensorial feedback. Damage to the PNS is devastating because its regenerative capabilities are limited.

More than 1 billion people worldwide are affected by a PNS-related disability, of whom ~80% could be mitigated by a bionic device directly connected to the PNS. So, a universal nerve interface would provide a global solution.

This project aims to deliver the fundamental proof-of-concept of a universal neurophotonic interface (UNI) that bidirectionally addresses individual peripheral neurons.

In the long-term vision the UNI could bridge any bionic device to the PNS, allowing the brain to control the prosthetic and receive sensory feedback, i.e. to "feel". Such a nerve interface is currently lacking. Electrical interfaces are still too invasive and stiff, have low spatial specificity, and produce artefacts. Currently the most advanced solution is the use of electromyographic signals generated by the contraction of residual muscles, which are not bidirectional, not fast enough, are prone to mistakes, and require intensive training.[1]

In 2005 a revolutionary field emerged: optogenetics.[2-3] This involves expressing photoactive proteins in grown neurons to control and detect their electrical activity by light. Most research has been translated into brain implants; only limited research has focused on nerve interfaces.[4]
In this project we bring together cutting-edge technologies such as optogenetics, molecular biology, gene editing, photonics, biomedical engineering, and medical neurobiology to develop the proof-of-concept of an innovative and transformative bidirectional UNI.

Progress and Achievement

The project officially started in September 2023 by the employment of the first postdoc (Dr John Scott) who has experience in photonics fabrication, testing and modelling. We managed to hire a second postdoc (Dr Glena Travis) in October 2023 with experience in molecular biology, gene editing and stem cells.

On the Photonics side, we have changed the fabrication process for the high quality Si_3N_4 waveguide and grating couplers (Fig. 1a) to be more efficient and cost-effective in the manufacturing of larger number of these devices.

Each device allows light at a specific wavelength to be coupled into the waveguide, propagate with minimal loss and be remitted at a distance by another grating coupler (Fig. 1b). This grating coupler will be located in correspondence of each photoactive neuron and able to excite it at will.

Fig. 1b show that light can be efficiently coupled in/out to/from the test device, constituted by two grating couplers, two photonic tapers and one waveguide.

Fig. 1d shows a Scanning Electron Microscope image of the high-quality fabricated grating coupler.

We have re-designed this site to avoid using two different photonic chips as originally proposed, making the current chip truly bidirectional. Differently from any other photonic brain implant in the literature, where the excitation is optical and the recording is undertaken electrically, we are developing an all-optical photonic device which will interact with neurons bidirectionally and only with light, i.e. fully optical. This configuration solves the issue of having neurons in contact with the device (necessary if an electrical recoding site is implemented); indeed, our device would interact with neurons at a distance, without be necessarily in contact with them to detect their response.

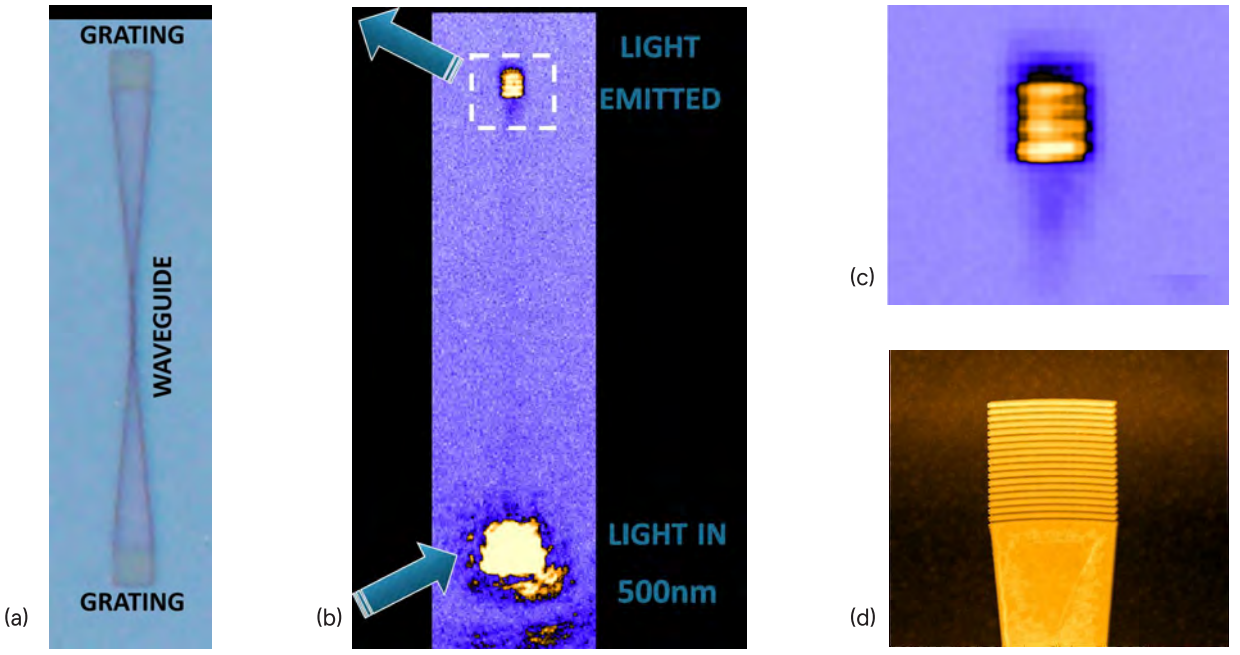


Figure 1. a) optical image of the test waveguide (in the middle) connected to the coupling gratings (top and bottom) via photonic tapers to allow the light to be efficiently coupled into the waveguide. b)optical image of light outcoupled from the device (top) after being coupled into the device by the other grating coupler (bottom) – we use a 500nm wavelength. c) enlarged outcoupling grating showing the light emitted. d) High resolution micrograph of the outcoupling grating (dimensions: 5µm x 5µm), highlighted by the white box in b).

On the biological side we have selected the most suitable activator/indicator combination that will be used to transfect the neurons, making them optogenetically active, as reported in the literature. We have already started growing the neurons in vitro, suitable for the first demonstration toward the end of the year.

Student Engagement

Given that the project started toward the end of 2022, we did not find any student to join the project. However, we have posted a related project in the Honours booklet in Engineering and in Physics.

We are also in the process of engaging an exchange Engineering student from Stockholm. The student will help us modelling part of the photonic chip.

We are in discussion with another student from Canada who wish to enrol in the PhD program here working on this project.

At the same time, we are looking for students to contribute to the project at the CMRI, where we grow the neurons, and at the CPC where we will perform the gene editing.

Associate Professor Stefano Palomba
Project Lead

Physics Grand Challenges 2022 Update
Quantum Many-body Techniques for Machine Learning

Aim and Background

Major problems across science and industry are characterized by large, complex time-varying datasets. Examples range from classifying unprecedented catalogues of pulsating stars to developing the algorithmic basis of precision medicine for tailoring treatments to individual health data.

The ability of machine-learning (ML) algorithms to accurately detect, understand, and classify complex patterns in these large datasets has advanced rapidly in recent years, driving progress on a range of exciting challenges, from language interpretation to automated driving. But our current best ML algorithms, typically based on deep neural networks, are challenging to interpret and can still struggle on data with complex correlation structures.

Improving ML algorithm performance and interpretability will have a major impact on emerging and established applications in science, health, and industry.

Our project develops a quantum-inspired approach to developing powerful new and interpretable statistical learning algorithms with the potential to yield efficiencies over existing schemes in training, performance, and interpretability.

Progress and Achievement

In 2023 we developed a working prototype quantum-inspired time-series classification algorithm. Our preliminary tests have been very positive—we have been extremely encouraged by results demonstrating that our initial prototype algorithm already displays performance consistent with the state-of-the-art neural-network-based time-series classifiers. Importantly, our approach is more interpretable and allows to determine what the algorithm actually learns.

Our strong preliminary results demonstrate the feasibility of our quantum-inspired approach and, through further refinement, strong potential to have a major impact on the field of time-series analysis.

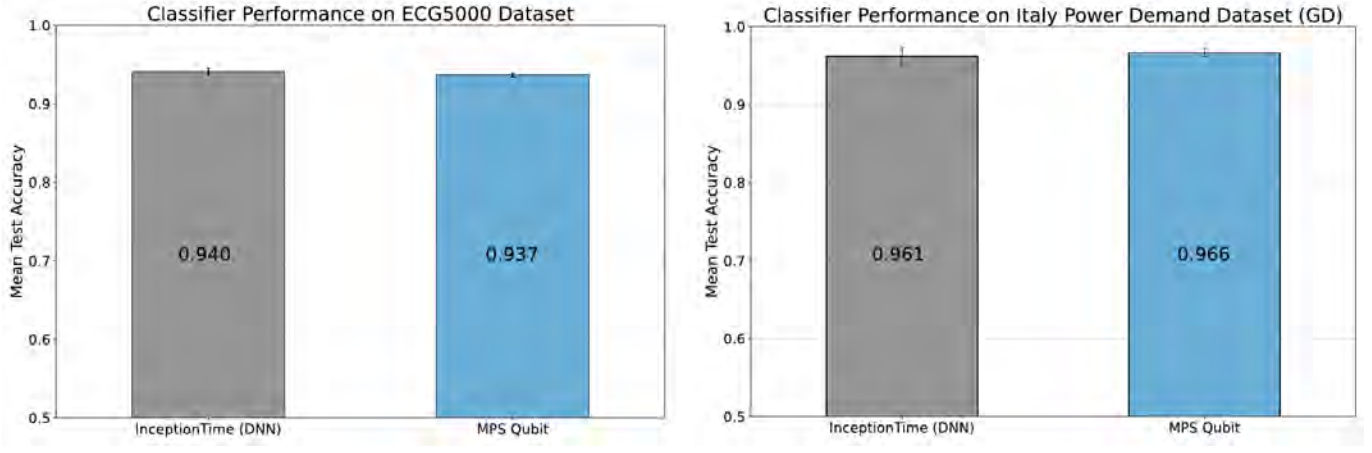


Figure 1. Comparison of our quantum-inspired tensor network approach with the state-of-the-art deep neural network Inception Time for two time-series classification problems. Left: Mean Test Accuracy for the ECG5000 dataset where the classifier needs to determine which of five classes an ECG trace belongs to. Right: Mean Test Accuracy for the Italy Power Demand dataset. The classifier determines whether a power use trace belongs to a winter or summer data set. In both cases our approach is state of the art.

Figure 2. Team members: (From Left to Right) Sahand Mahmoodian, Ben Fulcher, Joshua Moore, and Elaheh Mostaani.

Student Engagement and Team

We have used our project funding to hire two research assistants, Dr. Elaheh Mostaani and a recently graduated Physics Honours student, Joshua Moore.

Elaheh has been leading the literature review on tensor network approaches applied to other data types (not time series, e.g., images) and investigating optimal methods for encoding a real-valued time series into a representation as a quantum system.

Josh has been leading the implementation and evaluation of a practical algorithm on a database of time-series classification problems, as well as benchmarking against existing algorithms.

We have recently attracted a new Honours student, Angus Rutherford, for 2024 to work through some exciting new directions for these algorithms.

Strategic Planning

In 2024, our team will work towards some exciting extensions of our approach, including incorporating periodic boundary conditions, a stationarity assumption, and adapting our algorithm for forecasting applications. We also plan to publish our first paper on the approach this year.

As we move from a prototype to a fully optimized and tested algorithm, we will work through our interdisciplinary partners and industry mentor to find real-world impact on the myriad machine-learning applications involving time series—from time-series markers of ore deposits for mining, to brain-based biomarkers of psychiatric disease.

Dr Sahand Mahmoodian
Project Lead

Molonglo Telescope

Since opening in 1965, the Molonglo radio telescope has been a leading instrument for radio astronomy, with many research discoveries attributed to work undertaken at the site.

The telescope has played a pivotal role in the prominence of Australian astronomy over many decades.Highlights include the detection of quasar scintillation, the detailed mapping of the entire southern sky through the Sydney University Molonglo Sky Survey and the Molonglo Galactic Plane Survey, the pioneering discovery of a pulsar associated with a supernova remnant, Vela.
Most recently, Swinburne University led research that has resulted in the discovery of several Fast Radio Bursts and 30,000 timing observations of known pulsars.

Apart from its scientific accomplishments, Molonglo also served as a learning and training hub for multiple generations of radio astronomers. Dozens of PhD students have been trained at the site under the guidance of dedicated academic staff, including the late Professor Bernard Mills, the late Professor Richard Hunstead, Emeritus Professor Anne Green, and Professor Elaine Sadler.

Collaboration has always been a cornerstone of the Molonglo Observatory's operation, with ongoing partnerships, such as those with the CSIRO and Swinburne University, contributing to its long-lasting success.

Images: Molonglo Telescope

Image: Talks, Molonglo Telescope Symposium

The Physics Foundation, through the vision and leadership of the late Professor Harry Messel CBE AC, largely funded the project to purchase the site and build the Molonglo Cross.

The University has operated the telescope and supported its numerous upgrades and redevelopments over nearly six decades, enabling it to retain its pre-eminence as a research and training facility.

Astronomers and students across the world have benefited from the data provided by this instrument and the innovative technology developments it has generated.

The telescope has now ceased scientific operations and the site is being decommissioned. This has been a difficult and emotional decision, but pragmatic. Funding large infrastructure by a single University is now essentially impossible.

To celebrate the impact and legacy of this telescope we held a Symposium on 11 October 2023 in the Chau Chak Wing Museum at the University, followed by a Celebration Dinner at the Grandstand venue.

The speakers at the Symposium reflected on the scientific discoveries made at the telescope and their wider impact on astronomy, but they also recognised its legacy in shaping the careers and capabilities of the many staff and students who have worked at the Observatory.Legacy exhibitions will be developed for the Powerhouse Museum and the Chau Chak Wing Museum.

It has been an amazing journey – thank you to all who have contributed over the decades.

Emeritus Professor Anne Green

Image: Group Photo, Molonglo Telescope Symposium

Professor Harry Messel International Science School ISS 2023

solve for x

"Thank you to the Physics Foundation for giving me this opportunity to attend ISS and live the best 2 weeks of my life!

Forever I will be thankful for the amazing friendships, experiences and activities. I hope the ISS runs as long as can be, and I will surely return as a staffie."

The International Science School is back - live, in person, and on campus

From July 2–15 2023 we welcomed the latest cohort of 112 scholars from across the globe to the University of Sydney for ISS2023, the 43rd Professor Harry Messel International Science School. The ISS is always a packed and exciting fortnight, and 2023's event was even more special as we celebrated our return to the traditional in-person format for the first time since 2019.

Our ISS scholars enjoyed daily lectures by inspiring scientists, tours of cutting-edge labs and facilities, hands-on experiments and thought-provoking workshops, and a slew of social events. We encountered new and unexpected challenges running an event of this scope in the post pandemic era, and our dedicated team of ISS staff took these on with professionalism and gusto.

Background

In late 2020, with the CVD-19 pandemic playing out across the world, the Physics Foundation and the University of Sydney shifted the scheduled ISS2021 program to an entirely new, innovative online model. Around one hundred scholars were selected from across Australia to take part in five days of interactive web-streamed workshops, lectures, and social activities. The online format was a huge success, and late in 2021, with the pandemic still playing out across the world, we decided to run the ISS again as an online program in 2022 as an extended week-long program, with the Australian students joined by scholars from New Zealand, the USA and Japan.

Feedback from in 2021 and 2022 showed that the scholars hugely appreciated and enjoyed the online events at a time when gathering in person was not possible and quality experiences were difficult to find. However, everyone involved — from scholars and staff, to Foundation members and University of Sydney organisers — knew that the ISS should return to the traditional, in person format as soon as possible.

With a deep breath, in late 2022 we committed to return to campus for the next International Science School in July 2023.

ISS2023: solve for x

We chose the theme "solve for x" to reflect the problem-solving aspect of research, where approaches, methods, and answers aren't known or even well understood in advance.

Image: Scholars getting hands-on with some experimental techniques.

As with many ISS themes from across the years, the breadth of "solve for x" allowed us to invite speakers and create activities across the STEM landscape. The scholars were inspired by lectures on Antarctic ecology and quantum computing, they performed experiments on future foods and four-dimensional billiards, and they met graduate students studying everything from solar cells to marine biology.

The ISS2023 Scholars

We invited all countries involved in recent in-person ISS events, and despite the break in continuity over the pandemic period we were thrilled to receive participants from all of them — including the return of Singaporean scholars for the first time since 2015. In total we welcomed 112 scholars — 61 female, 51 male — from the following regions.

Scholar numbers:

Australia 60: NSW 31 · QLD 7 · VIC 7 · WA 5 · NT 3 · SA 3 · TAS 2 · ACT 2 · China 10 · India 5 · Japan 10 · NZ 5 · Singapore 5 · Thailand 7 · UK 5 · USA 5

Included in the Australian cohort were our four talented, passionate Indigenous Scholars, from Aboriginal and Torres Strait Islander communities across Australia.

The overseas groups were accompanied by adult chaperones who helped to encourage and take care of their scholars, and who worked with the ISS staff team to provide a safe and inclusive environment for all students.

We are enormously thankful to the following organisations for supporting the selection, organisation, and travel of the overseas scholars:

- The Affiliated High School of Peking University, China
- Shanghai High School International Division
- The Raman Research Institute, India
- The Ministry of Education, Culture, Sports, Science and Technology, Japan
- The Royal Society of New Zealand
- The Ministry of Education, Singapore
- The Ministry of Education, Thailand
- STEM Learning, UK
- Higher Orbits, USA

For the selection of the Australian scholars we are grateful for the support of the Science Teacher Organisations in each state and territory, and the NSW Department of Education.

The ISS2023 Program

The ISS is an intense fortnight of lectures, talks, tours of the university's research facilities, hands on experiments, and social events.

The 43rd Professor Harry Messel International Science School officially began with the Opening Ceremony event, held in the Messel Lecture Theatre under the skilful direction of event MC, Prof. Alice Motion from the School of Chemistry. Uncle Michael West from the Gomeroi nation gave a warm and inspiring welcome to country, then Provost and DVC Prof. Annamarie Jagose welcomed all participants to the University of Sydney.

Image: The ISS2023 scholars, chaperones and staff,

"Thank you immensely for making this happen—the friendships and memories will last a lifetime."

Physics Foundation President Mr Michael Winternitz spoke to the scholars about the history of the ISS and Prof. Harry Messel, the program's founder and Mr Winternitz's grandfather. He then introduced Her Excellency the Honourable Margaret Beazley AC KC, NSW Governor and Patron of the ISS and Physics Foundation, who addressed the scholars and officially launched the program. Finally, The Hon. Anoulack Chanthivong MP, NSW Minister for Industry and Trade, Minister for Innovation, Science and Technology, spoke about the importance of the ISS in fostering innovation and promoting the role of STEM in society.

Following the Opening Ceremony the first lecture was delivered by Prof. Howard Wilson, previously Director of the York Plasma Institute and recently appointed Fusion Pilot Plant R&D Lead at the Oak Ridge National Laboratory in the USA. Prof. Wilson outlined the exciting and hugely challenging research underway across the world to achieve the first generation of nuclear fusion power plants.

The Lecture Series

The remainder of the lectures were also held in the Messel Lecture Theatre, the spiritual home of the ISS program. Eight leading researchers, selected for their research expertise, scientific reputation, and communication prowess, delivered two lectures each on their work and its impact on society. Each 45-minute lecture was followed by twenty minutes of Q&A with the scholars and, as ever, the standard of insightful questions was very high.

The lecture series comprised:

- Prof. Howard Wilson (York Plasma Institute, UK, and ORNL, USA) — The Future of Fusion Energy
- Prof. Alan Duffy (Swinburne) — The Hunt for Dark Matter
- Dr Anai Gonzales Cordero (University of Sydney, CMRI) — Stem Cell Medicine
- Dr Xanthe Croot (University of Sydney and ISS alumnus) — Quantum Computing
- Casey Handmer PhD (Founder of Terraform Industries and ISS alumnus) — Synthesising Hydrocarbons from Atmospheric CO2
- Prof. Liz New (University of Sydney) — Chemical Sensors
- Dr Elanor Bell (Aust Antarctic Division) — Antarctic Ecology
- and the irrepressible Dr Karl Kruszelnicki with his Great Moments in Science

Special Events:

Across the two weeks the scholars took part in several special events:

The ISS2023 Speed Meet & Greet - an opportunity for the scholars to chat with research students and staff from across the faculties of science and engineering at a 'trade-display'-style event. A wide range of researchers each set up a table with a talking point activity or object, with displays ranging from Gut Microbiology to Renewable Energy to Quantum Dots to Amazonian geography.

Science & Engineering Challenge - a popular mainstay of the program, scholars participated in a special ISS edition of the Science & Engineering Challenge produced by the University of Newcastle, where teams compete in a series of activities designed to encourage and reward problem-solving and teamwork, from bridge building to electricity grid design to code breaking.

The ISS Alumni Panel - four alumni from across the history of the program gathered to reflect on their ISS experience and where their careers have taken them. The current cohort asked questions about career and degree choices, and the collective wisdom flowed freely. The participants were:

- Roger Cohen (ISS1979), engineering degree from Sydney, now founder and CEO of startup C2ZERO
- Casey Handmer PhD (ISS2003), degree at Sydney, PhD at Caltech, now entrepreneur and founder of

Image: Uncle Michael West from the Gomeroi nation delivers the Welcome to Country at the Opening Ceremony.

Image: Scholars testing their bridge designs during the Science and Engineering Challenge.

"The lectures excited me, inspired me, and motivated me to learn something new. The activities and workshops were great opportunities to learn science deeply."

- startup Terraform Industries, producing synthetic fuels from atmospheric CO2 and cheap solar energy
- Dr Xanthe Croot (ISS2007), now lecturer in experimental quantum computing at Sydney
- Kate Fiumara (ISS2017), now completing her degree in medical science and mathematics at Sydney and senior member of the ISS staffie team

Ethics and Leadership in Science Workshops - originally developed in conjunction with the USA's Smithsonian Institution and delivered by Gemma Smart and Eamon Little, grad students with the university's Unit for History & Philosophy of Science, these workshops challenge the ISS scholars to think through key ethical issues in modern science. After warming up with some classic examples such as the infamous Trolley Problem, students broke into groups to discuss and debate moralistic and ethical aspects of issues such as nuclear weapons research, Big Pharma, and climate change.

In parallel with the lecture series, a range of tours, hands-on activities and workshops were organised to give the scholars further exposure to science at the University of Sydney. Students enjoyed a behind-the-scenes tour of the university's new Chau Chak Wing Museum, and participated in a wide range of hands-on activities and experiments staged by the schools of Ag Science, Biological Sciences, Chemistry, Geosciences, Mathematics, Marine Ecology, Molecular Biology, Physics, and Psychology. These workshops and experiments were designed to build skills and show aspects of these disciplines beyond the normal classroom experience, as well as show off the range of educational and research facilities across campus.

Social Events:

The program of social events form a key facet of the ISS fortnight, providing opportunities for scholars to meet and form friendships, as well as a chance to explore the city and let off steam after a busy day at the university campus. The socials program was run by ISSSS, the ISS Social Squad, a troupe of university student volunteers under the leadership of two amazing coordinators, ISS alumnus Emily Rozanc, and Education/Science student Lan Tran, who both worked tirelessly to pull off an astounding range of events and activities.

The program included a trivia relay race, a bush dance, visits to the Sydney Observatory visits, city tours, a visit to Taronga Zoo, movie nights, and many more external and in-house events. The ISSSS team's commitment to delivering these engaging activities was invaluable to the success of the program as a whole.

The scholars themselves helped to organise the infamous ISS Talent Night in the second week, with acts ranging from traditional dances and songs from the international students, to individual scholars showing off their musical, comedy and magic skills.

The traditional ISS Harbour Cruise took place at the end of the first week, where all scholars and ISS staff enjoy dinner and dancing against a stunning backdrop of the city, Opera House and Harbour Bridge by night.

Image: Dr Karl takes questions from the scholars.

"The best thing about ISS was meeting all the new people there that were like-minded. Sometimes the people similar to you are very close by, and you just need to break out of your shell to find out. "

Gala Reception

The ISS Gala reception, held on Thursday 13 July in the University's Great Hall, was an opportunity for alumni, donors, friends and staff of the University of Sydney to meet the ISS scholars first hand. MC for the evening was Sleek Geek, radio and TV presenter Adam Spencer, who kept the more than 400 guests entertained throughout and ensured the event ran smoothly.

Joining the ISS2023 scholars and staff at the event were many university staff and faculty, numerous alumni from across the many years of the ISS (including many from the online events in 2021 and 2022, gathering in person for the first time), supporters and donors to the Foundation and the ISS, and Consuls General or their representatives from the Sydney consulates of China, India, Japan, New Zealand, Thailand, Singapore and the USA.

Uncle Michael West once again gave a welcome to country, and Prof. Tara Murphy, Head of the School of Physics and Director of the Physics Foundation, welcomed all to the University. Foundation President Michael Winternitz then spoke about the ISS program's history and the Physics Foundation's support for excellence in STEM education and research.

Three important scholar awards are announced at Gala reception: the Len Basser Award for Leadership in Science, the Mulpha ISS Award for Leadership, and the Albert Wong Award for Excellence. The ISS staff select the winners of these special awards, based on close observation of the scholars over the two weeks. At this year's Gala the awards were presented by Physics Foundation President Mr Michael Winternitz and University of Sydney DVC of Education Prof. Joanne Wright.

The Len Basser Award is presented to the scholar who, across the ISS fortnight, demonstrates leadership in science through a combination of originality of thought and a willingness to assist other scholars. WA scholar Pippa Bouteloup was this year's Len Basser awardee.

The Mulpha ISS Award for Leadership recognises international kinship and cooperation, and is awarded to a student who displays diplomacy, friendship, encouragement and understanding of fellow students from all cultures. This year the recipient was NSW scholar Hannah Smedley.

The Albert Wong Award for Excellence was initiated in 2019, in recognition of the many years of support for the ISS of long-serving member and past-President of the Physics Foundation, Mr Albert Wong. The recipient of the award embodies the spirit of excellence central to the philosophy of International Science School and the Physics Foundation. The 2023 recipient was Singapore scholar Aislinn Goh.

The ISS2023 scholars were then invited onto stage in their country and state groups to receive medallions commemorating their participation in the program. For the overseas scholars, these were presented by consuls general or their representatives from their local embassies, and Australian scholars received theirs from Foundation President Michael Winternitz and DVC of Education Prof. Joanne Wright.

On behalf of the scholars, Singapore scholar Aislinn Goh addressed the audience, speaking on the experiences of the ISS fortnight and

Image: Aislinn Goh receives the Albert Wong Award for Excellence.

"This was the best thing that I have ever done and am so grateful for the opportunity ... Thanks for an amazing 2 weeks, I will never forget them."

the impact of attending the program. The formal event was closed with an address by the Dean of the Faculty of Science, Prof. Marcel Dinger, who then invited guests and scholars to mingle and enjoy refreshments in the beautiful surrounds of the Great Hall.

The ISS Book & Lecture Videos

We produce a book to accompany every International Science School, with interviews with each of the invited lecturers discussing their work, influences and experiences, and thoughts on the future of their disciplines. The ISS book is a cross-section of the cutting-edge of science at that point in time; it is both an introduction to a wide variety of scientific disciplines and a unique historical document.

All participants received a copy of the book on arrival. Copies were presented to each lecturer at the conclusion of their talk, and were also given to friends and supporters of the program. The book is available to download in PDF and e-book formats from the ISS website:
sydney.edu.au/science/iss

We also record the lectures and upload the series as video to the official ISS YouTube channel. The entire ISS2023 lecture series, along with past series going back to 2005, is available at:
youtube.com/TheSydneyISS

Behind the Scenes

The Amazing ISS Staff Team

The success of the ISS relies on a vital group of twelve dedicated, capable and endlessly enthusiastic volunteer staff — the "staffies" — drawn from past ISS cohorts. In 2023 we prioritised staff with in-person ISS experience, selecting as many as possible from 2019 and earlier programs, alongside a smaller group from the 2021-22 online events.

The staffie team gathered from across Australia and — building on strong trans-Tasman staffie traditions of recent ISS programs — welcomed four members from New Zealand. The team bonded throughout training and handled the wide array of challenges every ISS brings with humour and determination.

For many decades the ISS staff team has included two House Parents, taking on the important role of pastoral care for both scholars and the volunteer staffies, as well as assisting with day-to-day logistics and planning. Unlike the other staff, the House Parents received a modest remuneration in recognition of the added responsibilities of the role. In 2019 we farewelled our long-standing HPs, John and Karen, after fifteen years in the role.

Their departure provided an opportunity to rethink our staffing structure in general, and in 2023 we broadened the House Parent role into three paid Senior Staff positions. These staff again carried responsibility for pastoral oversight of the scholars, alongside individual responsibilities covering oversight of the daily program, staff training and scheduling, and staff care.

Our three Senior Staff — Emma Hogan (scholar at ISS2017), Emma Clignett (ISS2013), and Kristy Armitage (not an ISS alumnus but highly experienced in similar programs) — handled the new roles with great enthusiasm and professionalism, and have provided a solid base for the ISS to further evolve the staffing structure.

It is impossible to overstate the devotion of the staff team to the ISS program, who gave their all to the two weeks of around-the-clock on-call duties (plus months of training and planning) to ensure the scholars enjoyed the best possible experience.

Image: Our dedicated staff team.

"Thanks from the bottom of my heart for organising this program, a most memorable two weeks for all of us!! ISS2023 was the epitome of excellence."

The University Faculty of Science Team

The other tireless and endlessly enthusiastic group driving the success of the ISS comprises the Faculty of Science Marketing and Communications team, with their creative and inspiring Science Communicators embedded in Schools and Departments across the university campus. From planning and logistics, to contracts and budgets, to managing major events like the Gala Reception and Opening Ceremony, to delivering the incredible array of experiments and activities — not to mention an endless stream of daily program requests like printing, copying, room booking, and volunteer wrangling — the Faculty team throw everything they have at ensuring the ISS achieves the highest standards.

A bright star amongst the Faculty constellation is ISS Program Officer Claudia Zhang. Claudia worked previously on the 2021 and 2022 online ISS programs, and 2023 was her first live ISS event. She patiently and conscientiously absorbed the minutiae of ISS organisational lore, and strove to deliver the very best on every occasion.

These groups of wonderful people make the ISS a truly life-changing event for so many scholars.

Accommodation

All scholars, staff and overseas chaperones stayed at Kincoppal Rose Bay School and Kambala School, neighbouring boarding schools in Sydney's Eastern suburbs.

This arrangement is not as ideal as staying on campus at one of the university's colleges: students do not get the same full benefit of living on a university campus, and the travel time is a significant addition to the ISS schedule that restricts the available time for other activities.

However, none of the university colleges show signs of mid-year capacity for the ISS group, and boarding at Kincoppal and Kambala has proven to be a workable option with some positive aspects. The schools are secure overnight and managed well, the catering is excellent ... and the views are second to none!

Planning Underway for iSS2025

Our return to the University of Sydney campus has reminded everyone close to the ISS of the significance of the in-person program. Scholars forge friendships, explore new ideas and directions, and make connections that are simply impossible in other ways. The online events in 2021-22 were necessary and valuable, but there is no replacement for the live International Science School spectacle.

That said, the world has changed in unexpected ways since our last campus event in 2019, and this year's ISS taught us much about the modern student experience, in particular issues around mental health. Planning is underway for the next ISS program in July 2025, building on our years of insight and incorporating the important new knowledge gained in running the first post-pandemic event in 2023.

In Conclusion

Experience is a funny thing. We have hosted International Science Schools for over six decades now, and we know so much about how to plan and execute this amazing program. Yet every ISS also brings new challenges, unexpected turns, and utterly novel perspectives.

While bringing the ISS back to campus in 2023 was exciting for everyone involved, it was a bit scary too. What if we suffered a major covid-19 outbreak — how would we care for the scholars and staff? How could we ensure everyone's safety while continuing to deliver a professional, inspiring event? And, most importantly, would we be able to get everyone home again at the end?

Image: Scholars exploring vitual worlds.

Image: The Scholars in the Messel Lecture Theatre.

As it turned out, we didn't encounter a covid wave this time; instead, other illnesses seeped in, bringing their own welfare and logistical challenges. But covid-19 remains around us in the background, and it will affect the risk assessment process for every ISS from now on.

More surprising for me was the changing outlook of our scholars and staff since the pandemic: always passionate, excitable, and keen to absorb as much science as we can throw at them ... and yet now carrying a sense of caution, a vulnerability in the world, that adds a new slant to our jobs as staff, organisers, mentors, and leaders.

I made reference above to the large team behind the ISS, the volunteers and university staff who work so hard to make this program great. I can't express enough how much I value their effort and dedication, and I know the Physics Foundation, the School of Physics, the Faculty of Science, and the University of Sydney as a whole, backs me on this: thank you.

ISS2025 will mark twenty years for me as Director: twenty years of surprises, excitement, laughter, and — yes, OK — some huge challenges and moments of deep frustration. I often joke that I spend the two weeks mostly yelling into microphones, but the truth is that I cannot imagine another job in this sphere with so much built-in reward. The scholars' feedback is testimony enough to the importance of what we do here, and we should never forget that.

Dr Chris Stewart
Director, The International Science School

" Thank you all so, so much for such an overwhelmingly amazing experience ... [it] might just be the best 2 weeks of my life! I hope it continues for decades to come."

Image: Scholars and staff enjoying the traditional ISS bush dance.

Dr Karl Kruszelnicki AM
Julius Sumner Miller Fellow Report

The University of Sydney Physics Foundation Established the position of Julius Sumner Miller Fellow within the School of Physics in 1995. Dr Karl Kruszelnicki has been the championing Fellow since, communicating the awe and wonder of science and inspiring students and the general public across a multitude of platforms.

University of Sydney Events

Karl was invited again to give two one-hour talks for the Leadership in STEMM subject for the University's high-achievers Dalyell stream. He presented a science communication workshop for the Faculty of Science HDR students and recorded some wonderful ocean-themed videos for the Ocean Lovers Festival in March.

The Australian Museum worked with Karl to promote the Sleek Geeks Science Eureka Prize across city and regional radio stations.

Karl's five-part lecture series for a first-year class in the Open Learning Environment Unit Sustainability: Climate and Energy ran again to great success over two semesters.

The Sydney Science Forum returned to the Seymour Centre with a bang – aptly named 'Great Moments in Science – Rolling Thunder'! Karl also gave two presentations for the International Science School students. At the end of the year, Karl was on a panel for the Usyd Alumni Festival.

Dr Karl was invited to Narrabri, to the University of Sydney agricultural research station for Field Day. He gave talks to local farmers, agribusiness, students, and the community, and according to the local paper he added 'star quality' to the day!

National Science Week

Karl's Science 'week' is really a fortnight starting in Hobart for a Science Communication talk at University of Tasmania, and a public show in Hobart and Launceston. A late-night, science-comedy show, and High School talk rounded off his Launceston visit.

Sydney Science Week kicked off with the NSW Department of Education hosting a webinar with Karl taking science questions from students all around the state.

The University of Sydney received a City of Sydney grant to produce the 'Dr Karl and Friends' show which lit up the Town Hall stage for an incredible night of science. Karl

Image: Still from Ocean Lovers Festival video. The powerful mantis shrimp has hammer claws!

Image: Professors Geordie Williamson, Anita Ho-Baillie, Michael Bowen, and Emma Johnston joined Karl for an evening of innovation.

chatted with four esteemed academics across a range of disciplines: AI, solar energy, neuroscience, and marine ecology. Associate Professor Alice Motion was the MC extraordinaire.

Karl contributed a question to the National Science Week Quiz and hosted the Usyd three-minute thesis competition. He finished his Science fortnight with a Climate Change talk and Q&A at Australian Museum, and Q&A at Sydney Science Trail, Mount Annan.

Schools

School science Q&As continued every week. Karl chatted with 78 schools across Australia and a school in London.

Karl visited schools throughout the year, inspiring students with his science talks and giving answers to their awe-inspiring questions. He visited St Mary's Cathedral College Sydney, for a spectacular Q&A, Darwin Middle School, and Bankstown Girls High to give a Future Careers in STEM talk.

The Sydney Morning Herald invited Karl to contribute to their HSC Study Guide, designed to support the 74,000 plus students sitting the exams in 2023. Karl shared his career pathway and practical tips for study and beyond.

Eureka School Prize

The University of Sydney Sleek Geeks Eureka Schools Prize is now into its eighteenth year.This year, students were asked to base their 2-minute films around the theme of 'Green'.The finalists in all categories enjoyed a lunch at the Chau Chak Wing Museum with Karl and Adam Spencer before enjoying the winner presentations in the evening at The Australian Museum.

Television

Karl appeared regularly on Channel Ten's*The Project,* explaining the latest science stories to a huge audience.

Radio

Karl's weekly five hours of national ABC science radio segments andCHAI FM in South Africa continued throughout 2023. He also added ABC Perth this year.Professor Geraint Lewis from Physics joined Karl for the triple j talkback Science Hour to take all questions cosmology. The triple j audience in just the five capital cities alone attracts over 750,000 listeners, while the podcast downloads were over 6 million.

Social Media

Karl's TikTok continues to be an incredible tool for engaging the public in science, followers now over half a million. Karl was featured in a 'TikTok for Good Campaign' where he shared his love of science and the joy he gets from imparting knowledge to others. The campaign played across social media, TV, and cinema.

The ABC also jumped on board Karl's TikTok following by inviting him to do some TikTok lives with ABC health reporters and University of Sydney PhD astrophysics student Kirsten Banks.

Image: St Mary's Cathedral College, Sydney

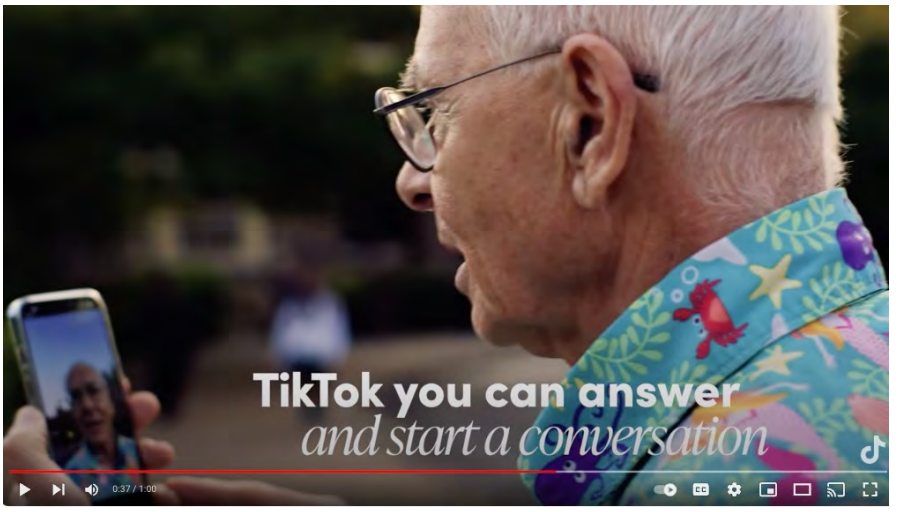


Image: Karl using TikTok to ignite science engagement.

Social Media Continued

The ABC also jumped on board Karl's TikTok following by inviting him to do some TikTok lives with ABC health reporters and University of Sydney PhD astrophysics student Kirsten Banks.

Karl's social media followers continue to grow with Facebook numbers now 188 K. Instagram followers are up to 133 K and X now sits at 339K.

Karl's website, drkarl.com is the go-to hub of all things Karl.

Karl's ABC radio profile expanded into his social media this year, resulting in three new social media videos series. Triple j produced videos with Karl and host Lucy Smith, as well as a science-movie series with Karl commenting on the accuracy of science in movies. Karl's long running Great Moments in Science podcast morphed into a weekly 'Science explainers' short video to huge success.

Podcasts

Dr Karl has a weekly triple j ABC podcast and University of Sydney podcast 'Shirtloads of Science' (average download per Shirtloads episode is 20K). Shirtloads featured Usyd academics such as 'Superstar of STEM' astronomer Dr Laura Driessen, and Dr Emily Remnant. Karl interviewed Associate Professor Lisa Piccirillo ahead of her Simon Marais lecture. He promoted, and drew listeners, to the new Usyd podcast 'The Solutionists' hosted by the Vice Chancellor, Professor Mark Scott.

Writing

Dr Karl continued his regular columns in*Australian Geographic*magazine and University of Sydney's*Science Alliance*newsletter (4000 members). He is in the process of writing his 48thbook – a long-awaited memoir.*The Sydney Morning Herald* invited Karl to contribute to their Study Guide to support HSC students. Karl provided written and video tips of encouragement for the students.

Festivals and Conferences

Karl returned as a mentor for scientists performing as The Steam Room for the Sydney Comedy Festival. They toured Sydney, Melbourne, and Brisbane with sold-out shows.

Karl also performed for the Big Cat Comedy Club in Darlinghurst. Continuing to reach new audiences through science comedy has been one of the great successes of the year.

Other festival appearances included Splendour, SXSW, and Woodford.

Image: still from ABC 'Science Explainers' video.

Image: Scientists and comedians join forces for the Sydney Comedy Festival at Enmore Theatre.

Overseas Activities

Karl journeyed to Antarctica during March as a guest speaker for Aurora Expeditions. During the trip he was interviewed for the online learning platform for children Upschool, for their course on the Solar System.

In April Karl gave a live-streamed 'Surfing Safari Through Science' talk, quiz, and Q&A for The Royal Institution in London. In October Karl again represented the University of Sydney giving talks in person at The Royal Institution and New Scientist in London.

Mentoring and Media/Speaker Training

Karl kicked off 2023 by presenting a fun, online science session about his career pathway and future careers in STEM for 600 Year 12 students attending the National Youth Science Forum. He mentored a young participant in Vision Australia's LEAP program by chatting with him over zoom about science and its wonders. He often invites people interested in science communication to join him at the ABC for his radio shows.

Karl was again involved in the ABC 'Top 5 Under 35' program which supports early science career researchers. The group spent a day at the ABC for some training and a science communication talk from Dr Karl.

It was another science-packed year for Dr Karl in 2023.

Image: Karl in London for New Scientist Live

Physics Foundation
Governance Statement

University Foundations are required to report to Senate. Summarised below is the Governance Statement Section to be reported upon as part of the Annual Report. The Annual Report prepared by a Foundation is to be submitted via the CFO to Finance and Audit Committee of the Senate.

The University of Sydney Physics Foundation recognises the importance and benefit of reviewing its adoption and alignment with governance principles and provides the following report.

Principle 1 -

Lay solid foundations for management and oversight

Nature of the entity

The Physics Foundation is a part of the University of Sydney ABN 15211513464 and not separately incorporated under a state or commonwealth Act. The Foundation is required to gain prior approval for its fundraising activities from the appropriate University delegate. The Foundation's activities are not-for-profit and covered by the DGR status of the University of Sydney. The University is exempted from the requirement to hold an Authority to Fundraise and obligations upon holders of such an authority but is still required to comply with the balance of provisions of the Charitable Fundraising Act.

Roles of board/ council and management

The Foundation operates under the authority of the Senate of the University of Sydney, as approved in 1954, and has no powers of delegation. The Foundation conducts its affairs pursuant to the Foundation Rules and the relevant policies of the University. The Foundation had its annual fundraising plan approved and was able to meet its objectives.

Principle 2 -

Structure of the council to add value

The Council of the Foundation in 2022 consisted of the following members. They were all eligible to attend three meetings in 2022, as well as the Annual General Meeting.

Executive

- Mr Michael Winternitz, President
  Appointment term: 2021 AGM
  Meetings attended: 3
- Mr James R Kirby, Deputy President
  Appointment term: 2021 AGM
  Meetings attended: 3
- Professor Marcel Dinger PhD, GAICD, FFSc (RCPA) (Research), FRSN, Dean, University Officer
  Meetings attended: 3

Members

- Professor Tara Murphy, Head of School
  Meetings attended: 3
- Dr Gregory Clark AC FTSE FAA FAPS
  Meetings attended: 2
- Emeritus Professor Lawrence Cram AM
  Meetings attended: 3
- Professor Gemma Figtree AM FRACP FCSANZ FAHA
  Meetings attended: 2
- Emeritus Professor Anne J. Green FTSE, FRSN, FAIP, FASA
  Meetings attended: 3
- Professor Greg McRae
  Meetings attended: 3
- Mr James Read
  Meetings attended: 3

Council members were elected at the Foundation's AGM on the 13th of March 2022. There is not a separate nomination committee of Council. The full Council resolves on nominations for co-opting of members to fill vacancies outside of the process of election at the AGM. There was no performance evaluation of the Council undertaken in the reporting period.

Principle 3 -

Promote ethical and responsible decision making

Council members have been provided with the University of Sydney

Foundation Rules, Code of Conduct, Work Health & Safety policy and the External Interests policy. All these policies are available on the University's Policy Register, as are other relevant University policies regarding harassment, grievance procedures and the Delegations of Authority.

Principle 4 -

Safeguard integrity in financial reporting

The annual accounts of the Foundation are prepared by the financial staff of the University, signed off by the Finance Director, Divisions of Natural Sciences, Engineering & Information Technologies and Business, and included in this Annual Report to the Senate. The Foundation is part of the University and therefore does not have its own audit sub-committee. While the Annual Financial Report of the University is audited by the Audit Office of NSW, the Annual Report of the Foundation has not itself been audited.

The Foundation undertook the following fundraising appeals during 2023: Donations.

In conducting those appeals the Foundation took all reasonable steps to ensure that commissions paid or payable to any person as part of a fundraising appeal did not exceed one-third of the gross money obtained by that person in the appeal and appropriate particulars of all items of gross income received or receivable, all items of expenditure incurred, including the application or disposition of any income obtained from the appeal and particulars of those transactions to which they related were recorded in the minutes of the Foundation.

Principle 5 -

Make timely and balanced disclosure

The Foundation complied with the reporting and disclosure requirements of the Senate. These include an annual budget and this Annual Report.

Members and Council have been made aware of the processes for disclosure pursuant to the Code of Conduct, External Interests policy, which include protected disclosure to the ICAC, to the Ombudsman or the Auditor General.

Principle 6 -

Respect the rights of shareholders, members, staff, volunteers, clients and other stakeholders

The Foundation Council and/or membership consist of members of the community, industry bodies and the University whose input is invited via the Annual General Meeting and Council meetings of the Foundation. The following forums/mechanisms have been held during the year to involve stakeholders in election of the Council, activities of the Foundation or other stakeholder participation.

Invitations are issued to

- The Annual General Meeting
- Two Council meetings
- ISS Opening Ceremony
- School Prize Awards Night
- Grand Challenge Pitch Night
- Grand Challenge Awards Night

Under the Charitable Fundraising Act, the University may be questioned about any appeal on details of the purpose of the appeal such as the appeal target, objectives, distribution of proceeds, and the process to provide answers. During the year the Foundation published information on is website, via email newsletter and outlines those activities in this annual report.

Specific requests for information are responded to by the Foundation office. Other enquiries may have been made to other parts of the University.

Principle 7 -

Recognise and manage risk

The Foundation recognises its activities within University premises or other premises require risks such as health and safety, environmental protection, privacy, trade practices, and compliance with the Charitable Fundraising Act to be considered and managed. The Foundation has managed these risks during the year by adhering to University policies concerning events, publications and external relations activities.

Principle 8 -

Remunerate fairly and responsibly

No member of a Council is entitled to receive any remuneration for acting in that capacity except reasonable remuneration on a basis which has first been approved in writing by the University Officer (Foundations) Members of the Foundation Council may be reimbursed for reasonable expenses after written approval of the University Officer (Foundations). Any such instances are recorded in the minutes of the Council.

Certificate of Operations

THE UNIVERSITY OF SYDNEY

Annexure 1

TO: **Financial Control and Treasury**

FROM: **University Officer (University of Sydney Physics Foundation)**

DATE:

SUBJECT: **Certificate of Operations - 2023**

CERTIFICATION

I hereby certify that the activities reflected in the Financial Statements for the year ended 31 December 2023 of the University of Sydney Physics Foundation fully complies with the Foundation Rules.

Any areas of non-compliance or departure from such governing rules have been advised in writing to the Provost / Deputy Vice-Chancellor responsible for the overall governance of the Foundation's operations.

Signature
University Officer (Foundation)

Prof Marcel Dinger, Dean, Faculty of Science

Name (Please Print)

Date: 22/02/2024

Balance Sheet

The University of Sydney

Uni of Syd Physics Foundation (L7500_SCI_FND_PHYS)

Balance Sheet

as at 31 December Calendar Year 2023

	Note	31 December CY2023	31 December CY2022
ASSETS			
CURRENT ASSETS			
Short Term Funds	3	(592,429)	546,525
Total Current Assets		**(592,429)**	**546,525**
NON CURRENT ASSETS			
Medium/Long Term Investments	3	35,159,618	33,834,275
Total Non Current Assets		**35,159,618**	**33,834,275**
TOTAL ASSETS		**34,567,188**	**34,380,799**
LIABILITIES			
CURRENT LIABILITIES			
NON CURRENT LIABILITIES			
NET ASSETS		**34,567,188**	**34,380,799**
EQUITY			
Accumulated Funds		34,567,188	34,380,799
TOTAL EQUITY		**34,567,188**	**34,380,799**

Notes to Financial Statements

1. Accounting Policies
   - The financial statements have been prepared on a modified accrual accounting basis.
   - Employee entitlements for Long Service Leave are held centrally in the University's accounts.
   - The University (including the Foundations) is exempt from income tax.

2. The funds reported herein are overseen by the Physics Foundation, which was set up by the late Professor Harry Messel to promote education and research in the physical sciences. These funds are used to support the International Science School (which runs biennial events for high achievers in senior high schools throughout the world), with surplus, annual investment returns made available, subject to Foundation and University Treasury approvals, to support the School of Physics in its teaching and research endeavours.

3 . Short Term and Long Term Investments include $7,696,706 of the Messel Endowment ($7,227,5480 in 2022) managed by the University of Sydney to retain its value in accordance with the commitments made by the Foundation when the Endowment was established.

Income Statement

The University of Sydney

Uni of Syd Physics Foundation (L7500_SCI_FND_PHYS)

Income Statement

for the Period Ended 31 December 2023

	Note	31 December CY2023	31 December CY2022
INCOME			
Grants		0	0
Scholarships, Donations and Bequests		17,470	1,550
Business and Investment Income		70,800	21,320
Realised Gain / (Loss) on Investments		2,413,181	625,310
Investment Administration Fee		(121,554)	(115,972)
Internal and Other Income		1,698	12,000
Total Income		2,381,595	544,208
EXPENDITURE			
Salaries	4	916,163	949,662
Consumables		4,758	3,103
Equipment and Repairs/Maintenance		2,653	14,184
Physics Grand Challenges Seed Funding	5	1,067,950	2,050
Catering Services	6	142,529	8,417
Travel, Conferences, Entertainment	7	321,479	9,148
Consultants and Contractors		5,486	8,564
Student Costs and Scholarships		32,808	34,864
Other expenses	8	74,613	414,995
Total Expenditure		2,568,439	1,444,986
Surplus / (Deficit)		**(186,844)**	**(900,778)**
Accumulated Funds		34,380,799	34,966,317
Accumulated Funds Adjustments		373,233	315,261
Total Accumulated Funds		**34,567,188**	**34,380,799**

Notes to Financial Statements (....continued)

4. The 2023 salary expenditure of $916k includes $246k of ISS-related salary expenses and $660k of education related funding support for the salaries of six School of Physics staff members.

5. The Grand Challenge Seed funding has increased in line with the re-start of research activity after COVID.

6. Catering services for ISS participants who attended in person for the first time since COVID.

7. Travel and accommodation for ISS participants who attended in person for the first time since COVID.

8. Other expenses no longer include Cost Centre Allocations (CCA) in operating expenses.

I certify that the Income Statement and Balance Sheet of the Foundation have been prepared in accordance with the University's accounting practices and procedures. These Foundation accounts form part of The University of Sydney's financial reports.

Thomas Sapina
Digitally signed by Thomas Sapina
Date: 2024.02.21 11:41:19 +11'00'

Thomas Sapina
Associate Director Finance
Faculty of Science

Carma du Plooy
Digitally signed by Carma du Plooy
Date: 2024.02.21 12:08:37 +11'00'

Carma Du Plooy
Finance Director
Financial Services - Science, Engineering and Architecture

For more information
The University of Sydney Physics
Foundation