University of Sydney Physics Foundation

THE UNIVERSITY OF SYDNEY

Annual Report for 2022

"The Physics Foundation core aim is to promote excellence in Science & Education"

Emeritus Professor Harry Messel AC CBE

We acknowledge the tradition of custodianship and law of the Country on which the University of Sydney campuses stand. We pay our respects to those who have cared and continue to care for Country.

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Annual Report 2022

Contents

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President's Report
Michael Winternitz

It is an honour & privilege to present the 2022 Annual Report for the University of Sydney Physics Foundation.

The past year has seen the Foundation continue to provide consistent financial support to the School of Physics, via a range of initiatives, as it has proudly done for nearly 70 years.

The School of Physics continues to excel in its pursuit of excellence in Science and Education, continuing a proud tradition of being one of the leading research institutions in the country, playing host to five Australian Research Council Centres of Excellence (ARC), one National Health and Medical Research Council Centre of Research Excellence (NHMRC CRE), an ARC Training Centre and two Cooperative Research Centres (CRC).

It is also pleasing to see such a strong focus on promoting excellence in Education within the School. On a macro level, the Foundation continues to support Professor of Science Education, Majula Sharma, Director of the STEM Teacher Enrichment Academy, a world renowned leader in science education.

Equally as important, it is exciting to see a diverse group of recipients of School awards and scholarships, supported by the Foundation over the past year.

The Professor Harry Messel International Science School (ISS), remains at the forefront of the Physics Foundations core objectives, as our flagship biannual event.

The Foundation elected to hold an special interim ISS online in 2022, to build towards a return to our regular tradition of a biannual, in person ISS. We look forward to welcoming the world's youngest & most brilliant scientific minds, to the University of Sydney in July 2023.

The Foundation's support for School of Physics Grand Challenges continues. This continues to foster collaborative work within the University, and great research outcomes. We are pleased to provide an update of several grand challenge projects, and also introduce our most recent winners in 2022.

The Physics Foundation has done and will continue to support the School in various initiatives. However, continued uncertainty around global economic conditions will mean the Foundation will need to focus very carefully to preserve the capital raised, such that we can continue to provide consistent support to the School into the medium & longer term.

On behalf of the Physics Foundation, I would like to to warmly thank Professor Céline Boehm for her excellent tenure as Head of School.

On that note, we warmly welcome Professor Tara Murphy as the new School Head. Tara has an incredible history with the School, and brings a great deal of energy and vision, as outlined in a special feature piece, I would certainly encourage you to read.

The Science Faculty, also welcomes a new Dean, with the appointment of Professor Marcel Dinger PhD, GAICD, FFSc (RCPA) (Research), FRSN. On behalf of the Physics Foundation, we welcome Marcel and look forward to working closely together.

I would like to express a sincere thank you to the excellent work of all the staff and students from the School during the past year.

The outlook for 2023 reflects an important year for the Physics Foundation, where we plan to reconnect with our Alumni, industry, and donors, whilst at the same time continue to provide consistent support to the School of Physics.

A sincere thanks to Deputy President Mr James Kirby for his support & guidance, and my fellow council members.

Michael Winternitz

President

Physics Foundation
Objectives and Aims

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 the 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. These generous supporters are acknowledged in the Messel Endowment Honour Board that is published on the Physics Foundation website.

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 2022, the Endowment holds $7,227,548 in funds. During 2022, donations and bequests to the Foundation totalled $1,550.

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.

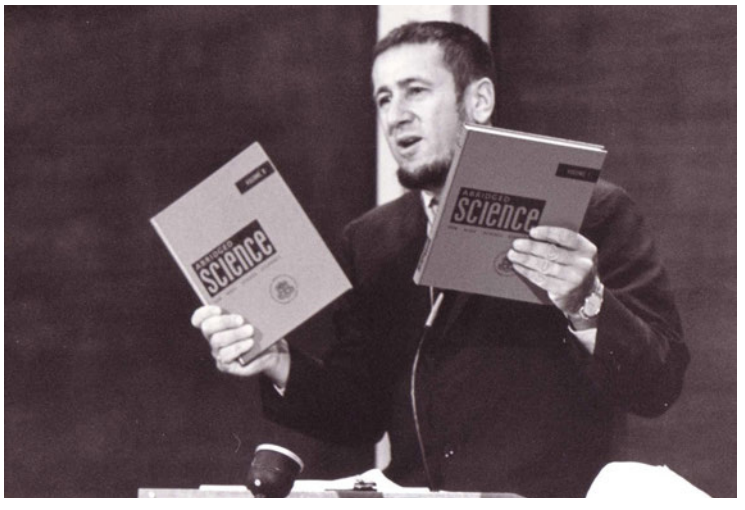
Donations of $2 dollars and over are tax-deductible. Pledged gifts (donations spread over a three to five year period) are welcome and are also tax-deductible.

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 www.sydney.edu.au/science/schools/school-of-physics/physics-foundation.html



LEFT: Professor Harry Messel AC CBE established the ISS in 1958.

Head of School's Report
Professor Tara Murphy

I am honoured to be writing my first report as Head of School of Physics, having started in the role in December 2022.

As I start my term as Head of School, I am conscious of the long and proud history of the School of Physics, and of the critical role that the Foundation has played throughout this history.

First, a little bit of background about me, and my journey in the School. I was the first in my family to attend university, and completed my undergraduate degree at the University of Sydney, majoring in physics and applied mathematics. An honours project supervised by the late Professor Richard Hunstead set me on my course of research in radio astronomy.

After doing my PhD at the University of Edinburgh on the Sloan Digital Sky Survey, I completed a postdoctoral position at CSIRO, before coming back to Sydney on an ARC fellowship. I have worked at Sydney ever since, building my research group studying radio transients (extreme astronomical phenomena that change rapidly) on next generation telescopes such as the Australian SKA Pathfinder (ASKAP) in Western Australia.

Throughout my education and my subsequent career I have always found the School of Physics a very welcoming place, but after several years of the pandemic, we, like many other workplaces, are feeling a sense of disconnection. One of my first goals is to rediscover our connections and build a stronger community, for both staff and students, whether we are working on campus or remotely.

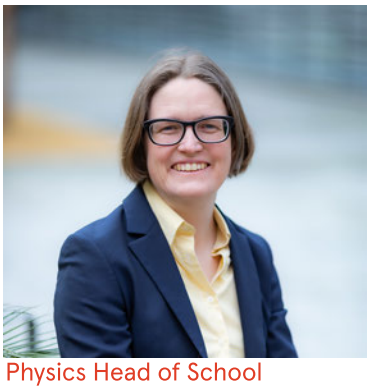
The School of Physics has a long record of research and teaching excellence. We have great strengths including talented, committed staff; intelligent, creative students; high impact basic research and an increasing strength in commercialisation and social impact. However, we are currently in a time of significant disruption, with the changing nature of the higher education sector, and the challenges of adapting to a post-pandemic world.
My vision for the School is that we can adapt and thrive in the face of these challenges, while not losing the many things that make us successful.

In education, our focus will be to deliver a world-leading, modern physics education. We need to adapt our lectures, tutorials and experimental laboratories to modes of teaching that allow the flexibility in learning that today's students expect. We need to make physics relevant and interesting for a more diverse student cohort, and in particular, centre it as a critical discipline for solving complex social challenges, such as climate change.

In research we aim to become the leading school of physics in Australia. We need to build on our success in high impact basic research; while at the same time embracing opportunities to commercialise our research, and to form strong connections with external organisations, working together to increase the social impact of our research.

An area of growing importance is our connection with industry and other external partners. We have some successes already, but we need to build on these to make industry connections part of the fabric of our School. This will have benefits that span education (e.g. highlighting career opportunities for our students) and research (e.g. identifying potential connections and collaborations), as well as enriching our culture by making stronger connections with our alumni.

The Foundation has an important role to play in all of these areas, and I look forward to working with the Foundation, alongside the staff in the School of Physics and the wider university, to build on existing programs, and implement some new initiatives to support these goals.


Physics Head of School

2022 Physics Foundation Members

Foundation Staff

- Mr Justin Noble, Liaison 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)
- Mr J Keith Campbell CBE (1975)
- Mr Herman D Huyer AO OON (1978)
- Mr Raymond J Kirby AO (1982)
- Mr John R Slade (1986)
- Mr Peter Douglas (1989)
- Dr Peter Jones AM FTSE (1993)
- Mr Paul Slade (1996)
- Mr Graham Hall (1999)
- Mr Pat Donovan AM RFD ED (2002)
- Mrs Louise Davis AM (2005)
- Mr Trevor Danos AM FTSE (2008)
- Mr Jim O'Connor (2011)
- Mr Albert Wong AM (2013)
- Emeritus Professor Anne Green AM 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 AM FTSE FRSN FAIP FASA (2006)
- Professor Clive Baldock (2010)
- Professor Tim Bedding FAA (2012)

Foundation Council 2022

Office Bearers of the Foundation

- Mr Michael Winternitz, President
- Mr James R Kirby, Deputy President

University Officer

- Professor Iain Young, Dean of Science (outgoing)
- Professor Philip Gale, Interim Dean of Science (outgoing)
- Professor Marcel Dinger PhD, GAICD, FFSc (RCPA) (Research), FRSN (incoming)

Council Members

- Dr Gregory Clark AC FTSE FAA FAPS
- Mr Trevor Danos AM FTSE (Observer)
- Professor Gemma Figtree AM FRACP FCSANZ FAHA
- Emeritus Professor Anne J. Green FTSE, FRSN, FAIP, FASA
- Professor Greg McRae

University Ex Officio Council Members

- Ms Melissa Bonevska
- Ms Alexia Nicholson

Foundation Members

Founder

- Emeritus Professor Harry Messel AC CBE

Life Governors

- Mrs Louise Davis AM
- Associate Professor Robert Hewitt
- Dr David Mills AM
- Mr Jim O'Connor
- Mr Martin Rogers
- Mr Paul Slade
- Mr Albert Wong AM
- Prof. The Hon. Dame Marie Bashir AD CVO
- Mr Trevor Danos AM FTSE

Honorary Governors

- Mr Tony Aveling
- Emeritus Professor Max Brennan AO FAA
- Emeritus Professor Richard Collins FTSE
- Professor Lawrence Cram AM
- Mr Raymond Kirby AO

Individual Members

- Dr Gregory Clark AC FTSE FAA FAPS
- Professor Gemma Figtree AM FRACP FCSANZ FAHA
- Emeritus Professor Anne Green AM FTSE FRSN FAIP FASA
- Mr James R Kirby
- Professor Greg McRae
- Mr Michael Winternitz

Corporate Members

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

Physics Grand Challenges
2022 Round

The Physics Grand Challenges were established in 2019 and aim to support unconventional, innovative, interdisciplinary research projects with a total of $250,000 each to be awarded, for up to two projects.

A live audience pitch event was held on 14th November, including five project leads who presented their ideas to the Selection Panel with a 10-minute Pitch followed by a 5-minute Q&A.

The 2022 Selection Panel included several council members and prominent persons:

- Mr Michael Winternitz, President of the Physics Foundation.
- Professor Gemma Figtree AM FRACP FCSANZ FAHA, a world leading cardiovascular researcher and practioner.
- Mr Trevor Danos AM FTSE, company director and strategic adviser for a range of government and private organisations
- Dr David Mills AM, a world renowned expert on non-imaging optics.
- Mr Adam Lister, a leading business executive.

2022 Winners

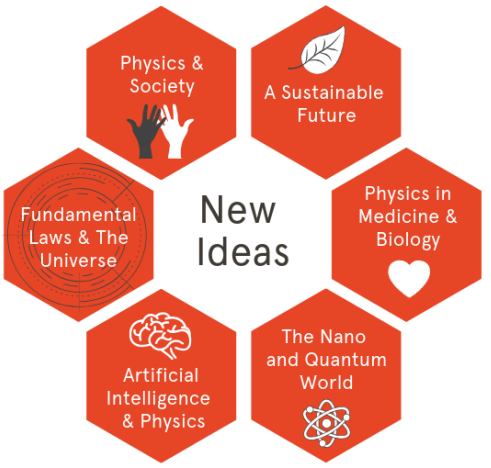
Assoc Prof Stefano Palomba - Universal Neurophotonic Interface: Bionics with "Feeling" - Awarded $250,000 over 2 years
More than 1 billion people worldwide are affected by a Peripheral neuropathy-related disability (PNS).

PNS is a serious condition resulting from damage to your peripheral nerves – outside your brain and spinal cord. 80% of conditions could be helped by a bionic device connected to the PNS with a universal bi-directional nerve interface in a bionic prosthetic.

The team are working on a long-term vision allowing the brain to control the prosthetic and receive sensory feedback, i.e. to "feel".

Prof Rongkun Zheng BSc (SDU), PhD (HKUST) - X-ray Imaging Based on Metal Halide Perovskites - Awarded $250,000 over 2 years
This project aims to demonstrate single-pixel X-ray detectors and multipixel X-ray imagers based on their patented direct epitaxy of high-quality single-crystalline Metal Halide Perovskites.

The expected outcome is X-ray imaging technology



with much higher sensitivity and greater confidence in the accuracy of imagery than current MRI and X-Ray imaging.

Additionally, this new approach will exhibit much lower radiation dosage than current X-Ray technology, and is expected to be of significantly lower cost than current MRI technology.

Dr Sahand Mahmoodian - Quantum many-body techniques for machine learning ($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.

The winners and the panelists for the 2022 Grand Challenges. FROM LEFT TO RIGHT: Mr Michael Winternitz, Dr Feng Li, Mr James Kirby, Assoc Prof Stephano Palomba, Dr Alessandro Tuniz, Mr Adam Lister, Dr David Mills AM

Physics Grand Challenges 2019 – Update
The OAASIS Project

Project Lead: Dr Joy Murray

Aim and Background

Our vision is to supply a free tool so that all organisations big and small can identify modern slavery risk in their supply chains. We believe that everyone should be able to access and afford the tools needed to address modern slavery.

OAASIS (Open Analysis to Address Slavery in Supply chains) was built on two years of School of Physics, ISA (Integrated Sustainability Analysis) research into slavery in the supply chain prior to Australia's introduction of a Modern Slavery Act. The research drew on the expertise of ISA alumna Dr Darian McBain and Co-Directors of StoptheTraffik, (now BeSlaveryFree) Carolyn Kitto and Fuzz Kitto. Meetings in 2019 brought together these and other experts to discuss two knowledge gaps pertinent to reporting under the Act: How do we know our supply chain (ISA's core business); How do we deal with modern slavery when we find it (Dr McBain & BeSlaveryFree's expertise).

The 2019 Grand Challenge grant enabled formation of the OAASIS project with funding to address the first of these gaps. Our primary commitment was to develop a supply chain data visualisation tool.

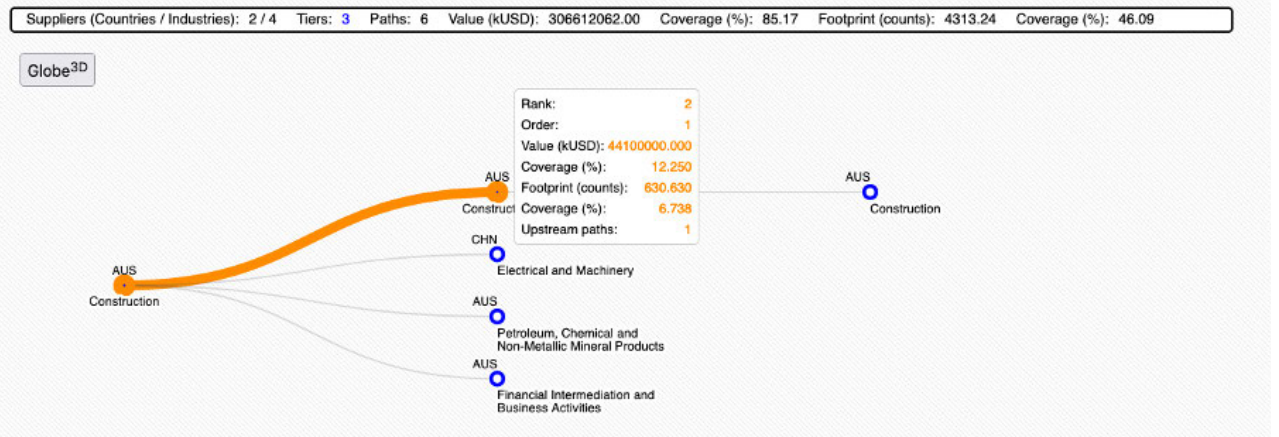
Footprint visualisation tool

To produce modern slavery footprints the tool uses modern slavery data, currently forced labour data, and the GLORIA (Global Resource Input-Output Assessment) supply chain database built by the University of Sydney for the UN International Resource Panel. The tool's output is a quantification of modern slavery risk by sector and country, as well as visualisations of the supply chain networks upstream of the organisation.

The tool visualises supply chains as a tree. Each node in the tree represents a transaction in the organisation's supply chain and a modern slavery risk. (http://www.physics.usyd.edu.au/spajs/)

Each node is labelled with the supplier country. Hover over any node and the user sees the rank order of that node's contribution to the footprint (i.e. from highest to lowest contributor), its tier in the supply chain (i.e. immediate supplier, supplier of supplier etc), the dollar value and percentage of the organisation's spend on that input, the node's footprint and its percentage of the total footprint. Thus, an organisation can easily identify in which country and sector of the economy the greatest risks of modern slavery are likely to be, reducing enormously the task of identifying and therefore addressing modern slavery in the supply chain.

BELOW: Screenshot of supply chain data visualisation showing detail available at each node. Each node in the tree represents a transaction in an organisation's supply chain and a modern slavery risk.



LEFT: Dr Joy Murray at the Grand Challenge Awards Night (2022) explaining how virtual reality will enable people to see what it's like working on a sustainable cocoa farm.

Progress Update and Achievements

1. **Supply chain visualisation tool** (spaJS) beta version using ghg emissions data completed 2021 and open for feedback (http://www.physics.usyd.edu.au/spajs).
2. **Two new data visualisations** (map projection and globe projection) added in 2022, thanks to Dr Thorsten Tepper-Garcia who continued to work on the project pro bono throughout the year.
3. **Data forced labour footprint data added** 2022 thanks to Dr Jacob Fry who is providing his time pro bono. Dr Fry has also enabled moving spaJS from dependency on the EORA database to use of the updated GLORIA database. Funding has been provided by the University's Modern Slavery Unit to employ a research assistant throughout 2023 to assist in extending the modern slavery footprint data sets.
4. **A 360 degree video clip** with voice over by Fuzz Kitto showing cocoa farmers in Eastern Ghana at work on their farms. The final OAASIS commitment was to create a 360 degree video clip to use as a pitch for funding to accomplish our next task: create education materials to fill the knowledge gap identified by respondents to the Modern Slavery Act. Ms Bridgette Ofosua Addo, Ministry of Food and Agriculture, Ghana, did the video work. The video was edited by Oliver Heath.
5. **Academic paper published:** "Towards an Emissions and Modern Slavery Impact Accounting Model". Environmental Science and Technology 56 (16) 2022
6. **Further tool development** Carolyn Kitto and Fuzz Kitto (Be Slavery Free) have introduced us to members of the Attorney General's Modern Slavery and Human Trafficking team who are researching accessible and available tools for Government and reporting entities. The tool was shown to them at a meeting in February and a follow-up meeting is being arranged.
7. **Funding has been provided by the University's Modern Slavery Unit** to further develop the data platform, produce the University's Modern Slavery Footprint and provide a training module on use to the footprint tool.
8. **Funding is being sought to build a user friendly data input mechanism** and front end to the tool; these are the only impediment to commercialisation.
9. **Tool Pilot** - The Business Council for Sustainable Development Australia has offered to pilot the tool.

Impacts

The most significant short-term impact has been achieved by OAASIS members – representatives of government, business, academia, NGO and civil society – who have shared knowledge, collaborated and disseminated our learning throughout their own considerable and influential networks. All have contributed to the design and development of a supply chain analysis tool that will enable users to see their supply chain and the modern slavery risks therein, no matter how far along the chain those risks are. Outputs from the tool are downloadable for inclusion in reports and presentations. Currently the tool includes: forced labour data generating a forced labour footprint; and greenhouse gas emissions data generating a carbon footprint, which is included to demonstrate the power of the tool as well as linking the concept of a 'modern

slavery footprint' to the well-established carbon footprint. A user friendly data entry and front end will be built and new data sets added progressively, after which the tool will be made publicly available.

The most significant long-term impact on organisations will be the ability to identify where in the supply chain modern slavery risks are hidden. Knowing where to look saves time, effort and money that instead can be used to address the problem on the ground. The tool provides a wealth of information, outlined above, that will direct effort to where it is likely to be most effective. This tool will help businesses understand their modern slavery footprint in Australia and beyond, to address and minimise the fundamental risks of slavery in supply chains as well as aid compliance with Modern Slavery Acts.

Future Research

Three OAASIS members are nominated Chief Investigators (CI) and two OAASIS members are Partner Investigators (PI) on a Linkage Project Application led by Macquarie University: Eradicating Modern Slavery from Australian Supply Chains. If funded we will: build on the use of the SpaJS data visualisation tool to enable companies to identify modern slavery risks (lead organisation USyd OAASIS); establish best practice guidelines for key at-risk industries and products to help identify, eradicate and report modern slavery (lead organisation Macquarie); develop a scorecard that enables Australian companies to be ranked on their performance in eradicating modern slavery from their supply chains (lead organisation Wollongong & Adelaide); provide evidence-informed recommendations to the Commonwealth on future changes to The Modern Slavery Act 2018 and the National Action Plan to Combat Modern Slavery 2020-2025 to help strengthen the regulation and make it more effective (Macquarie).

- Dr Joy Murray

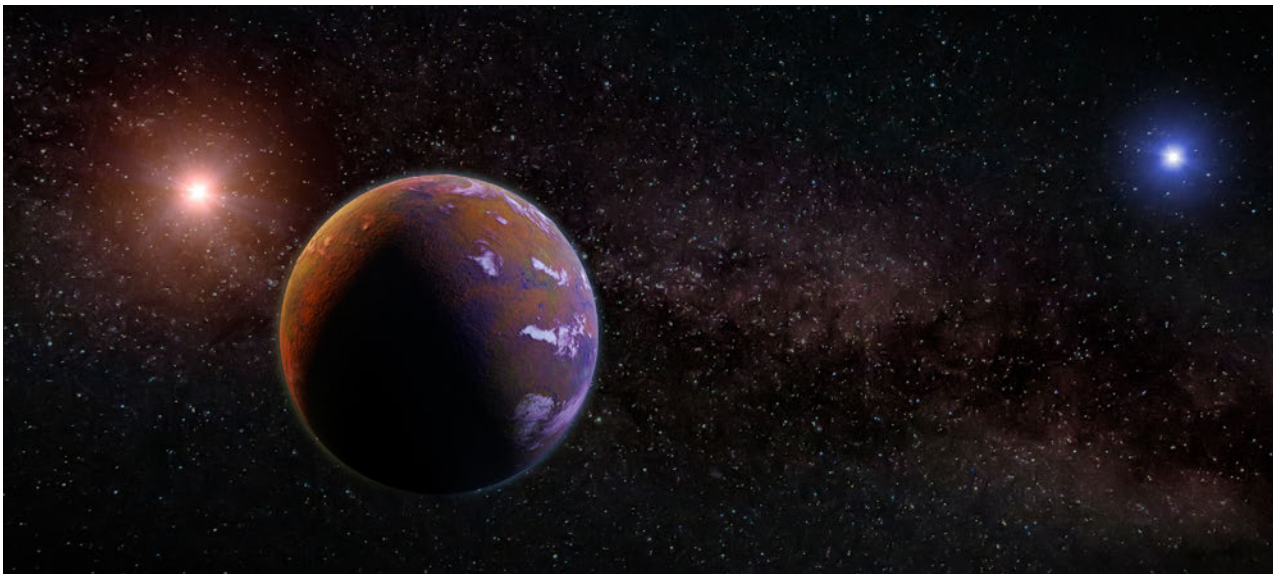
Joy Murray holds an Honorary Senior Research Fellow position in the School of Physics. Prior to her retirement she was as Senior Research Fellow with the Integrated Sustainability Analysis (ISA) group in the School of Physics where she led the School's OAASIS project (Open Analysis to Address Slavery in Supply Chains). She has edited and co-authored seven books on supply chain analysis.

BELOW: Cocoa farmers from the Akote and Osino communities in the Eastern Region.

Physics Grand Challenges 2019 – Update

Mission to α-Centauri

Project Lead: Professor Martijn de Sterke



Conventional spacecraft would take 80,000 years to reach our nearest star system, Alpha Centauri. The Starshot program aims to build laser-powered sails that could complete the journey in just 20 years.

Aim and Background

The Breakthrough Starshot project, coming out of the United States, aims to send small probes to the Alpha-Centauri system, the star system closest to Earth.

The idea is that the probes will be propelled by an Earth-based laser which accelerates them to 20% of the speed of light in approximately 15 minutes.

It would then take approximately 20 years to reach Alpha-Centauri, covering an enormous distance of 4 light years. The probes will have the shape of a sail with a diameter of a few metres, but with a mass of only a gram.

This is a very ambitious project that requires major advancements in several areas in science and in engineering including material science, space communications, lasers, heat management, etc.

The Physics Foundation Grand Challenge project Mission to Alpha-Centauri aims to contribute to one aspect of this large project by analysis of the launch phase.

The launch phase is very delicate as the motion of the light sail tends to be unstable. That is, any unavoidable imperfections in the light beam cause the sail to shake and to veer off course, leading to a failed mission. We have been working on the stabilisation of the light sail while it is being propelled by the laser.

Progress Update and Achievements

Our team consists of members of the School of Physics, with backgrounds in optics, astronomy & space physics, and dynamical systems, and of the School of Mathematics & Statistics.

Our approach is schematically summarised in the image on the next page: the sail consists of different parts that can move with respect to each other (indicated in blue and in grey).

When they do so, there is friction (green), which not only reduces the relative movement but also dampens the shaking of the sail as whole.

Using advanced techniques in theoretical mechanics, our analysis of the movement of the sail demonstrates that it can be stabilised in this way.

We also show that the heat that is generated by the friction is likely to be small compared to the unavoidable absorption of energy from the laser beam.

So far, existing research has been based on unrealistic assumptions including infinite 'stiffness' of the sail and so does not bend and only modelled in 2D. We have extended modelling into 3D and demonstrated viability without ‘infinite stiffness’.

Our work has been published in Physical Review Applied. However, we also found that achieving stability is not guaranteed and appears to depend on the details of the sail properties in a way that we do not understand yet.

Acquiring this understanding is on the agenda for 2022-23. We are fully embedded in the Starshot program and have acquired further funding to tackle these challenges.

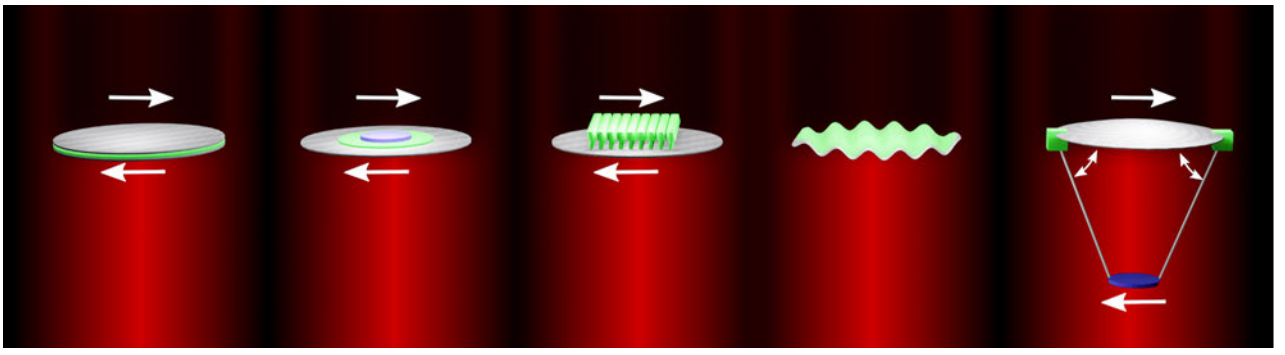
Student Engagement

Several undergraduate students have contributed to our project and indeed three of them are authors of the journal paper mentioned above. We are also preparing an experiment for the undergraduate teaching lab demonstrating the pressure exerted by a light beam.

- Prof Martijn de Sterke

Prof Martijn de Sterke PhD, FAIP, FOSA is a physics theorist here at the University of Sydney, with research interests in optics, photonics and electromagnetism. He has published more than 300 journal papers and has many accolades under his belt including Esther Hoffman Beller Medal “for far-reaching contributions to optics and photonics education and has recently been appointed to be involved in the ARC Centre of Excellence Optical Microcombs for Breakthrough Science.

BELOW: Schematic of a possible implementation of the passive stabilisation of a light sail consisting of two parts (grey and blue) that sandwich a region (green) that acts as a spring with dampening. The arrows indicate the motion of the top and bottom parts.



Physics Grand Challenges 2020 – Update
Positronium the key for cancer annihilation

Project Lead: Dr Yaser Hadi Gholami

Aim and background

For cancer patients, time is a matter of life and death: identifying early-stage cancers will save lives. Detection of cancer well before any symptoms and micro-metastases is the key for a good prognosis.

The overall aim, is to develop a novel anti-matter marker, positronium, with quantum sensitivity and specificity for early cancer diagnosis, a medical technology not previously recognised. The benefits will include higher resolution, less harmful radiation to patients and much lower costs compared to MRI scans.

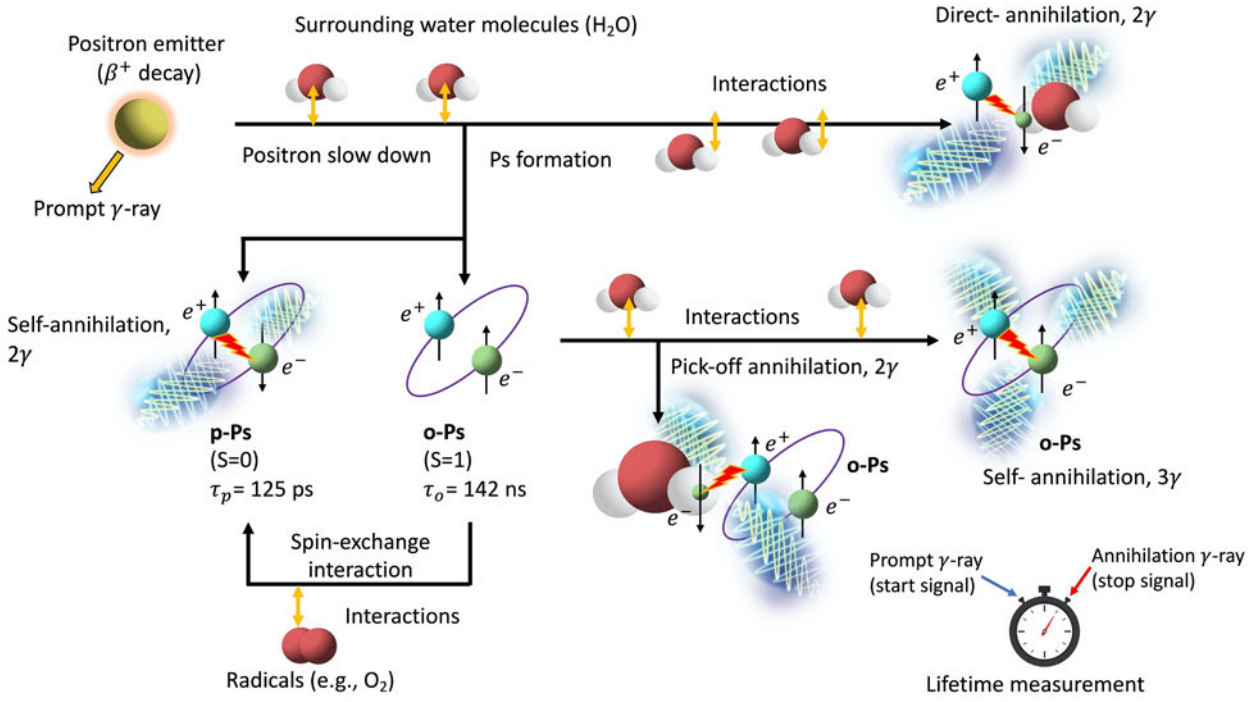
Progress Update and Achievements

We have designed a Positronium Annihilation Lifetime Spectroscopy (PALS) unit that can specifically be used for studying cancer cells using positronium, this advancement has been achieved through engaging PhD, master students and collaboration with top world experts.

We have finalised the design that is required for studying both healthy and cancerous cells using the PALS unit study. We are currently in the process of commissioning the PALS unit with the Dtect Innovation company to meet our required design for the parts. The PALS design was further discussed with an international expert Dr. Mihael Makek from Zagreb University. We have established a collaboration work with Dr. Makek's group for further experimental and educational work.

Furthermore, a Monte Carlo simulation platform was developed in GATE/GEANT4 software to simulate the decay of different states of positronium in cancer and healthy cells. This simulation platform can measure the lifetime of different positronium states (in different medium including tissue) and number of gammas from its decay. These results will be validated by the PALS measurements. Moreover, while we are waiting for the commissioning the PALS unit, we have begun our investigation in the use of quantum information for Positron Emission Tomography (PET) image

BELOW: Schematic diagram showing the possible pathways for positronium formation and decay in living materials.



reconstruction (a process where the information from the PET scan is used to generate an image). We are hoping to translate our PALS work into in-vivo imaging (using Total Body PET scanner) which will be installed this year at the Royal North Shore Hospital. The result from our PALS project can potentially lead into developing a new PET imaging modality which we call, Ortho-positronium Emission Tomography (OPET) (which would require a new reconstruction technique (such as the one mentioned above).

Student Engagement

Last year a new PhD student, Michael Alexander Lloyd, has joined Dr. Gholami's team. As a part of his PhD, he will be working on this project and further develop the project. Apsara Tennakoon, a former USYD master student also has joined the team and she has developed a Monte-Carlo simulation platform for simulating the ortho- and para-positronium decay.

Currently she is trying to further expand her work to simulate the PALS experimental set-up in the GATE/GEANT4 software. This year, we are also looking for a second year student from the School of Physics to work on the use of quantum information in PET image reconstruction.

International Workshop

Yaser's work has gained international acclaim and he has been asked to provide a lecture for the University of Zagreb, Croatia called, *Positronium - from Quantum Physics to Medical Applications*.

The workshop, organised by the Department of Physics, Faculty of Science, University of Zagreb will gather experts in the field of positronium-related physics, both from theory and experiment, fundamental and applied, in order to present and discuss the results of their research and emerging topics.

Yaser will be sharing recent results on positron annihilation localization by nanoscale magnetization and/or studying the quantum properties of cancer cells using positronium

lifetime spectroscopy.

Dr Yaser Hadi Gholami

Dr Yaser Hadi Gholami is a physicist in the field of applied physics in nuclear medicine. His research (at both clinical and pre-clinical level) has been focused on the fields of nanomedicine, radionuclide therapy and imaging, radiation physics and biology, nuclear chemistry and Monte Carlo simulation.

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Physics Grand Challenges 2020 – Update

Nanoscale brain navigation for targeted drug delivery

Project Leads: Dr Ben Fulcher and Dr Shelley Wickham

Aim and Background

Brain disorders, including mental illness, dementia and brain tumours cost Australia over $74 billion dollars a year.

Yet 92% of all new central nervous system drugs fail at clinical trials because they tend to flood the brain and cause off-target toxicity, rather than target the specific area where they are required.

This Physics Grand Challenge project seeks to design nanoscale robots which could deliver drugs to the distinct regions of the brain where they are needed, transforming treatments and patient outcomes.

Progress Update and Achievements

In addition to regular interdisciplinary team meetings across our core team (spanning Physics, Chemistry, The Brain and Mind Centre, and Biomedical Engineering), the below details specific outcomes of our Grand Challenge project across both undergraduate and postgraduate research projects.

Student Engagement

We supervised a joint undergraduate student team of two second-year physics students and two engineering students. With guidance from PhD student Annie Bryant, the interdisciplinary student team worked together to evaluate the viability of a subset of proposed molecular targets for protein aggregates in Alzheimer's disease. The students leveraged a recently-published database of gene-expression signatures of neurons containing Alzheimer's disease pathological hallmarks, through which they learned to interpret advanced scientific literature and develop problem-solving strategies for state-of-the-art bioinformatics data. The team also developed a simulation model for simple spatial navigation at the nanoscale based on top candidate genes identified from the bioinformatics analysis. We also supervised two undergraduate Denison summer students, a Dalyell project student, and a 2nd year Physics Special Studies Program (SSP) project student on Grand Challenge projects. These four students all worked in the lab with postdoc Minh Tri Luu; their work aimed at gaining a fundamental understanding of the workings of DNA nanorobots' components. Dr Wickham also presented a related talk to the 1st year Physics Connect lecture series.

Team

Annie Bryant, who joined the project in 2022, has been successful in obtaining RTP funding for her PhD on Alzheimer's disease, which includes projects related to the Grand Challenge. Postdoctoral researcher, Dr Minh Tri Luu, who joined the team in May 2021, has also been very productive. He is designing and testing the primary functional components of DNA nanorobots and developing a scalable and high-throughput method for evaluating their performance once prototypes are completed. Additionally, we recently started working on a perspective article describing promising applications of DNA computing for modern problems in neuroscience, which will summarise the conceptual advances our interdisciplinary team has collectively made thus far.

ABOVE: From left: Assoc Prof Mac Shine, Ms Annie Bryant, Dr Ben Fulcher, Dr Shelley Wickham, Dr Minh Luu.

Strategic planning for continued funding

We are continuing to engage in meetings with the Advancement Team in seeking philanthropic support for the project's next steps.

– Dr Ben Fuller & Dr Shelley Wickham

Dr Ben Fulcher leads the Dynamics and Neural Systems Group in the School of Physics at the University of Sydney. He has a diverse and interdisciplinary training in physics, dynamical systems, brain modelling and statistical learning.

Dr Shelley Wickham is an ARC DECRA Fellow, Westpac Research Fellow and Senior Lecturer in the Schools of Chemistry and Physics at the University of Sydney.

Annie's Story
Attracting top talent to the School

The Foundation's core mission is about driving excellence in Science and helping the University attract the best talent from around the world giving opportunity to young bright stars.

Annie Bryant is one such bright star from the US. Funding from the Grand Challenges has enabled her to join Dr Ben Fulcher and Dr Shelley Wickham's team as a Postgrad to work on the Nanoscale brain navigation for targeted drug delivery project. Read about her experience moving to a new Country and how our academic community has inspired her.

Through the generous support of the Physics Foundation, I've just wrapped up my first year as a PhD candidate within the School of Physics at The University of Sydney – and what an incredible year it has been! I've joined an inspiring and welcoming academic community that has afforded lifelong friendships and unparalleled support and supervision.

I first visited Sydney in early 2017, as part of an exchange program through my alma mater – Northeastern University in Boston. Not only did I fall in love with this city, but I also experienced the uniquely immersive research culture that The University of Sydney has to offer. In my animal behaviour course, we spent afternoons recording sentinel behaviour amongst meerkats at Taronga Zoo and collected honeybees with pheromone-laden weather balloons to track colony migration. After I returned to Boston and finished my undergraduate studies, as I set my sights on further education through a PhD program, I knew without a doubt that The University of Sydney was the best place for me.

I found a project posting from my now-supervisor, Dr Ben Fulcher, seeking a PhD student to better understand nuanced differences in brain activity patterns among neurological disorders using methods for characterizing the dynamics of complex physical systems. Given my research background in quantitative analysis and neuroimaging, this felt like a natural fit.

From the get-go (back in August 2020), Ben has been unwaveringly supportive and encouraging – even though we both recognized that applying as an international student during peak COVID might be an uphill battle. Although it took some time for me to physically arrive in Sydney given border restrictions, this past year showed me many times over that joining this group and meeting all the amazing people that I have was more than worth that wait.

All of this was made possible by the Physics Foundation at The University of Sydney, which supported my Higher Degree by Research tuition during 2022.

This support directly enabled me to move to Sydney and commence my research program, for which I am exceedingly grateful.

In the past year, I have had the opportunity to present at multiple conferences with researchers from around the world – and have also been introduced to the magical art of the Australian lawn bowl, during a lab retreat to the Central Coast last year.

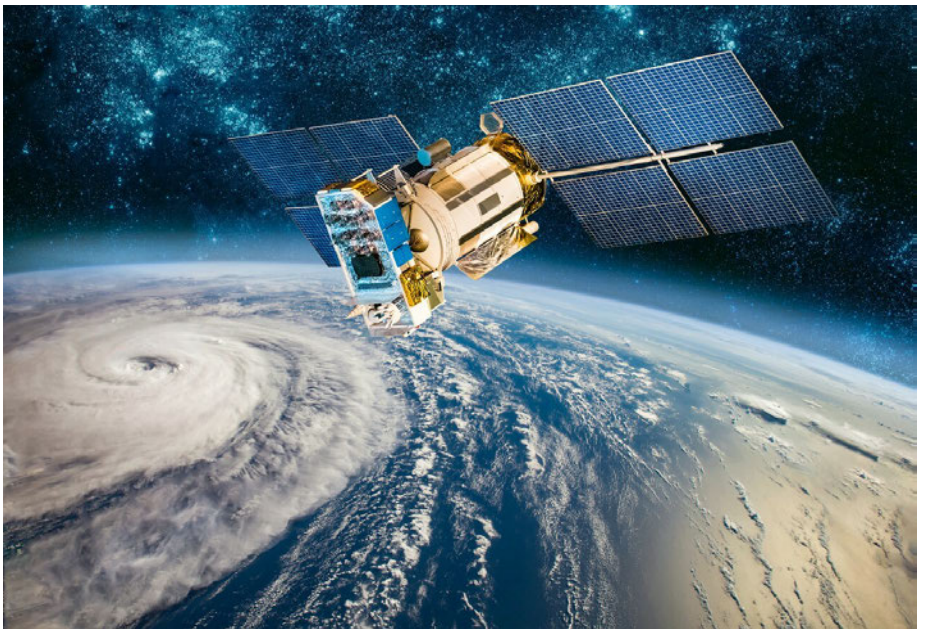
I couldn't imagine a better environment to learn and thrive as a young scientist, and I can't wait for what lies ahead with this program.

ABOVE: Annie (far right) works in Complex Systems - more specifically, her project is on the application of methods from complex physical systems to recordings of whole-brain dynamics.

Physics Grand Challenges 2021 – Update
Eye in the Sky

Project Lead: Professor Maryanne Large

Aim and Background



Working with Bush Heritage Australia, this project aims to prevent and reduce the severity of bushfires initially using drone technology and then satellites. We will develop advanced systems for monitoring ecological health, building bushfire resilience and better understanding the effects of bushfire. The scope of the project is to:

- advance and test novel instrumentation in the field (initially on UAVs and ultimately in space).
- detect and monitor volatile organic compounds (VOCs) emitted by plants and carbon budgeting associated with fire.
- monitor vegetation health and soil moisture and with 'ground truth' from terrestrial measurements - develop maps of landscape risks, prioritising interventions.

The project will develop two instruments, The first is an optimised "hyper-spectral" imager, which will collect information about the reflected wavelengths at each pixel. This detailed spectral information will give us insights into factors such as plant health, or the moisture content in the soil. We have already developed a hyper-spectral system for visible wavelengths, and are about to test a new version (see image) operating in the Infrared (IR) region. While hyper-spectral systems are not new, we will optimise our systems to give the most relevant information for the Australian ecosystems.

Progress Update and Achievements

The project formally commenced in August 2022 due to delays caused by the pandemic. Our first step was to recruit a post-doc to work on the project- which we have now done and we are pleased to welcome Dr Tanya Das who will join us in March.

We have made progress on the instrument development with physics PhD students- including an initial lab test of the new optical fibre sensor. While the sensor development is well underway in the lab, work is needed to extract the gas concentration from the measured signals in an computationally efficient way. In the field, measurements will be influenced by factors such as scattering in the atmosphere and the presence of other gases. To help us solve this problem, we have connected to Australian-based Harvard researcher (Dr Chris Chan Miller) an atmospheric chemist, and Dr Alison Wong - a data scientist now based in the School of business.

We have had ongoing meetings of the team and decided on an approach and sites for field testing. Initially, we will use sites close to the university before testing at one of three Bush Heritage sites. We have also submitted an EOI for funding through a Clean Tech grant.

A hyper-spectral system has been completed to work in the visible (CI Betters and Leon-Saval). A near Infrared instrument has been assembled (see image on the next page) and is awaiting field testing. We are now focusing on integrating these sensors on a drone (power, data, control, as well as mechanical issues such as mounting). We plan to run the first drone tests in the first half of 2023. Initially this will be done at the University's

Arthursleigh farm, in the Southern highlands. This site has facilities for the Australian Centre for Field Robotics (Director CI Manchester), including a drone pilot.

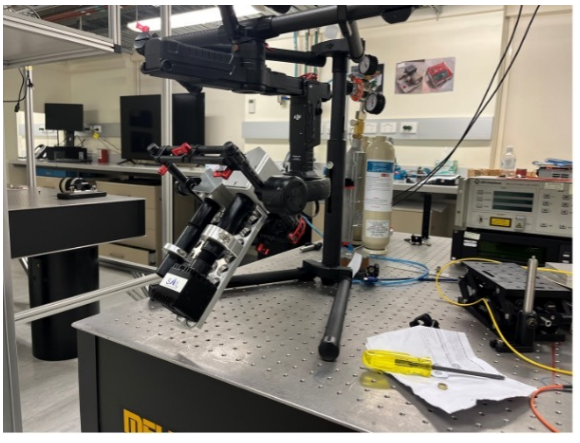
We have now made the specialised fibre grating for methane, and this has now been integrated into an initial sensor (lab based only at this stage). For the gas sensing, after the lab testing, we will work with CI Possel, who has facilities at the Camden campus for measuring gas emission from plants during fire. These experiments will be conducted in controlled conditions using a furnace.

In addition, we are working with a student-led group from the Australian Centre for Field Robotics (ACFR) to incorporate their edge computing system with our remote sensing systems. Their system, known as Numbat, allows onboard "sorting" of hyperspectral data so that unwanted data is excluded (eg: images obscured by cloud, blurred, of areas without features etc). This approach means that lower requirements for storage and downloading data, and faster feature identification. A prototype system has been made, which will need to be updated and integrated onto the drone for the initial flights.

We have had several meetings with the extended team to discuss field testing and how the group will work together. This work is at a relatively early stage.

We discussed potential sites for field testing with the team, and Bush Heritage. At the suggestion of CI Bell, we agreed to work initially with sites for which Bush Heritage has existing ecological data (in some cases going back 20 years), and which are simple in terms of vegetation structure. These are sites that have either grassland, or isolated trees, so that we can assess the soil, and its water content, directly. We are working with Bush Heritage to identify "gaps" in their knowledge of the system that they would like to track

BELOW: Image of the IR hyper-spectral imager mounted on a drone gimble. The sensor operates in the spectral interval 1588-1673 nm targeting both CO2 & CH4 absorption bands.



Student Engagement

PhD student Matt Rahme has built an initial lab-based version of the novel Bragg sensor. This is undergoing initial testing. PhD student Naif Alsalem hase been working on the IR hyper-spectral system. We have also partnered with six postgraduates from science and engineering who are developing an edge computing system for UAVs. This will allow much of the image processing/classification to be done on the UAV in real time, improving speed and efficiency. We have also set two third year group projects (3888 projects), which we hope will attract students.

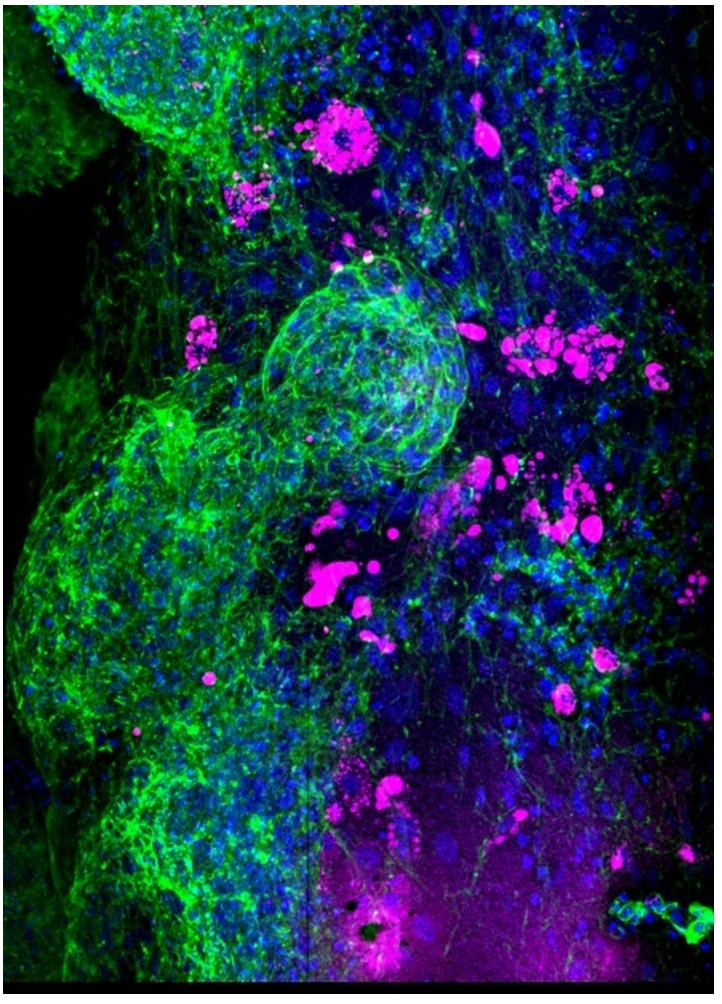
- Prof Maryanne Large BSc(Hons) PhD

Maryanne is a physicist with a background in optics and interest in developing high technology industry with real world impact. She is an Academic Fellow on the University of Sydney Senate.

She also promotes innovation and commercialisation within the Faculty of Science. She's currently actively campaigning to make Wombat Day (October 22) a National Holiday.

Physics Grand Challenges 2021 – Update
Function Follows Form: Next Generation Bioscaffolds

Project Lead: Professor Simon Fleming



ABOVE: Preliminary demonstration of proposed approach to cell growth

Aim and Background

This is a project to develop and demonstrate novel bioscaffolds suitable for synthetic blood vessels, and cardiac tissue led by Professor Simon Fleming.

Every year, millions of patients suffer tissue loss or organ failure. For the most part, physicians treat this by transplantation, surgical reconstruction, or using mechanical devices. Although these therapies have saved and improved countless lives, they are imperfect solutions.

The desire to rebuild damaged tissues has been a recurring theme of science fiction for decades. It seems magical, but also maddeningly within reach. After all, tadpoles can regrow their limbs, and lizards their tails - so why not us? The most ambitious vision of regenerative technology is less about "rebuilding", and more about "regrowing". The aim is to use the patient's own cells to regrow new cells on scaffold structures, allowing the regeneration of tissues and even organs, and avoiding the need for transplants. This approach offers the real possibility of treating a large range of currently untreatable or poorly treatable human diseases and injuries.

The project brings together expertise in the School on the fabrication of microstructures in bioresorbable materials and on the plasma functionalisation of their surfaces. Combining this with the expertise of collaborators in stem cell biology, the project will demonstrate a novel approach to fabrication of complex 3D bioscaffolds with application to clinical building replacement blood vessels and cardiac tissue.

The project received seed funding from the Physics Foundation following the Physics Grand Challenges 2020 round. The funding has assisted in the advancement of the project leading up to their successful outcome in the 2021 round.

Progress Update and Achievements

The critical step of hiring a postdoctoral researcher is our first and most important priority. At the time of

writing, we have a shortlist of potential postdoc researchers and are currently waiting for referee reports. They have very relevant recent experience, so we anticipate the work ramping up quickly. With existing staff we have developed some of the test substrate fabrication techniques.

The project is intrinsically interdisciplinary and connects the School to Faculties of Engineering (Schools of Chemical and Biomolecular Engineering, and Biomedical Engineering (BMME)), as well as Medicine and Health (School of Medical Sciences). We will be able to draw students from those disciplines into the School, including through co-supervision, as has already happened for Honours students. BMME in particular is a new School, which is actively recruiting staff and students, and we are able to leverage our strong professional links to access these students.

Student Engagement

Two Biomechanical Honours students worked on aspects of the project last semester. One worked on the influence of topology on cell growth, and the other on how to grow cells from dissimilar cell lines together. A publication has been submitted on the prior work, a Record of Invention is under discussion and there have been discussions with potential funding partners and about bringing the work within a proposed CRC.

- Prof Simon Fleming BSc, PhD, CEng, FIET

Simon Fleming is a research leader in photonics, with over thirty year's experience. His research has focussed mainly on optical fibre and has spanned all aspects, from materials and fabrication through to devices; and from discovery to applied. His research track record of over three hundred publications, twenty patents and numerous grants is complemented by extensive experience in working with industry and in the translation of research into commercial outcomes. He has supervised twenty research students.

International Science School 2022

Maintaining connections & building for 2023 ISS in person event

ABOVE:The Chief Scientist of Australia, Dr Cathy Foley, during the official opening event

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. We extended the program to include scholars from overseas, and expanded it to a full week of activities.

While scholar and staff feedback clearly shows a preference for the in-person experience, the online ISS2022 program was hugely popular and greatly valued by the vast majority of participants.

We are greatly anticipating the return of the in-person program in July 2023.

The ISS2022 Scholars

ISS2021 Online was limited to Australian applicants, while we experimented with the web-based format.

In 2022 we were determined to open the opportunity to our overseas partner countries again, and invited all of the organisations we last partnered with in 2019 to select students for the online program — of these, we received a positive response from New Zealand, Japan, the USA, while our partners in China, Thailand and India declined due to the ongoing pandemic situation in those countries. In total we welcomed 139 scholars — 87 female, 50 male, 2 non-binary — from the following regions.

Scholar numbers:

NSW: 56• QLD: 25 • VIC:20 • ACT: 3 • WA: 5 • TAS: 2 • SA: 5 • NT: 4 USA: 3 • NZ: 10 • JAPAN: 10

Our Amazing International Staffies

The volunteer staff team was once again comprised of enthusiastic past scholars, drawn from 2021, 2019 and 2017. The team included two staffies from New Zealand and, for the first time, one Japanese staffie who attended the ISS in 2019 and was a great help in

ABOVE: Prof. Alice Motion talks with Chief Scientist Dr Cathy Foley and the Governor of NSW, Her Excellency The Honourable Margaret Beazley AC QC

welcoming our Japanese scholars and communicating with them about the program. We hope this sets a precedent for further staff connections with Japan and other overseas countries in the future.

The Program & Platforms

From the success of the 2021 program, we carried over the use of both the Zoom platform for running lectures, panels, workshops and live lab tours, and using the Discord platform for mostly text-chat based communications, networking and information dissemination.

The scholars are very used to these platforms after several years of online or hybrid learning at school, and we found few difficulties bringing them on board. We will certainly be using these or equivalent platforms for future online and in-person events.

The Daily Program

Most days during ISS2022 were split into three parts: a lecture, a tour or activity, and a hands-on workshop. We kicked off with a special live and live-streamed event held in the Messel Lecture Theatre, with an audience of alumni, university staff, Foundation members and supporters of the ISS. The event was co-hosted by Prof. Alice Motion from the University of Sydney, in person from the Messel Lecture Theatre, and ISS Director Dr Chris Stewart online with the scholars.

The Foundation President, Michael Winternitz began proceedings with a welcome to all guests and scholars, followed by speeches from Vice Chancellor Prof. Mark Scott, the NSW Minister for Science, Innovation and Technology, and for Skills and Training, The Hon. Alister Henskens, the Chief Scientist of Australia Dr. Cathy Foley AO PSM FAA FTSE , and Her Excellency The Honourable Margaret Beazley AC QC, Governor of NSW and Patron of the International Science School. The Scholars were inspired by this formal event, with many expressing amazement at the breadth of VIPs supporting the program, and commenting that the welcome speeches made them feel honoured to be a part of the program.

The ISS Online Lectures

Each day began with a traditional ISS scientific lecture, the speakers selected for their area of expertise, scientific reputation and communication prowess. This year the lecture series featured:

- Prof. Elaine Sadler AO FAA (Sydney) — The Future of Radio Astronomy
- Blaise Aguera y Arcas (VP, Google AI) — The Future of Artificial Intelligence
- Prof. Veena Sahajwalla FAA FTSE (UNSW) — Green Engineering
- Ms Jacinta Cleary (Sydney) — Biomedical Engineering
- Prof. Anita Ho Baillie (Sydney) — The Future of Solar Energy
- Prof. Francois Aguey-Zinsou (Sydney) — The Hydrogen Revolution

BELOW: A live-streamed tour of Prof Ann Kwan's biosciences research lab

ABOVE: A panel of ISS alumni from across 4 decades shared their collective wisdom with the scholars

- and the ever-popular Dr Karl Kruszelnicki (Sydney) — Dr Karl's House Party

Also on the talks schedule was Prof. Adrienne Fairhall from the University of Washington and ISS alumna from 1987 — Adrienne spoke at ISS2021 and agreed to return again this year. At the last minute she was unable to deliver her talk, however we rescheduled and held a special ISS Christmas Lecture, bringing the scholars together once more to hear about Adrienne's amazing research on computational neuroscience.

Prof. Sadler delivered her talk from the Messel Lecture Theatre after the opening event; all the others were delivered from the speaker's home or office. The lecture series was recorded and has been uploaded to the official ISS YouTube channel: youtube.com/TheSydneyISS

Lab Tours

We organised three live-streamed lab tours during the week, taking in Anita Ho-Baillie's Solar Research Lab, the interdisciplinary biosciences Kwan Lab led by Prof. Ann Kwan, and Prof. John Bartholemew's Quantum Systems Lab in the Sydney Nanoscience Hub.

Learning from the challenges we faced with these tours in 2021, we managed to host these streamed tours with very few technical issues. Scholars asked questions of the researchers along the way, and greatly enjoyed the experience of exploring working research spaces across the university.

Workshops

As in the past, a highlight of the program was a series of hands-on workshops created especially for the ISS program by outreach teams across the Faculty of Science. Building on the robust feedback from scholars in 2021, the team produced another astoundingly successful set of experiments. All scholars — including those in other countries — received a box of materials in the mail prior to the ISS, complete with notes, simple DIY experimental apparatus, even basic chemical samples and mini microscopes.

The workshop creators brought superb energy and enthusiasm to the activities, and the feedback was once again enormously positive. We owe huge thanks to the Faculty team, and we look forward to seeing how these workshops evolve in the future.

Social events

The socials program continues to be a key element of the ISS — it allows the scholars to mingle and get to know one another, find and celebrate shared interests and passions, and forge new friendships. In 2021 my concerns about this aspect of the online event were swept away by the ingenuity and enthusiasm brought to

the socials program by the staffies, which infected the scholars who collectively created a vibrant and exciting shared space online.

This year the staffies ran social events involving streamed movies and TV shows, games tournaments, live quizzes and competitions — sometimes involving just individual groups of scholars, sometimes bringing the entire cohort together. We are still learning the best way to reach all scholars through these platforms, and no solution works for all kinds of people at all times. But through these early experiments, I am confident we can truly engage the scholars in a variety of ways outside the academic program during an online event.

The ISS Returns to Sydney in 2023

Late in 2022 we took the decision to run ISS2023 as an in-person event once more, and preparations are well underway for the program in July. Scholars will be flying in from all of our recent overseas partner countries — China, India, Japan, New Zealand, Thailand, the UK and the USA — and we will welcome back Singaporean scholars for the first time since 2015. We are preparing an exciting program of speakers and activities, and can't wait to welcome another fantastic cohort of talented scholars to the University of Sydney in July.

ISS2022 participant quotes:

"Thank you so much. This was a once in a lifetime life changing experience and I am forever grateful."

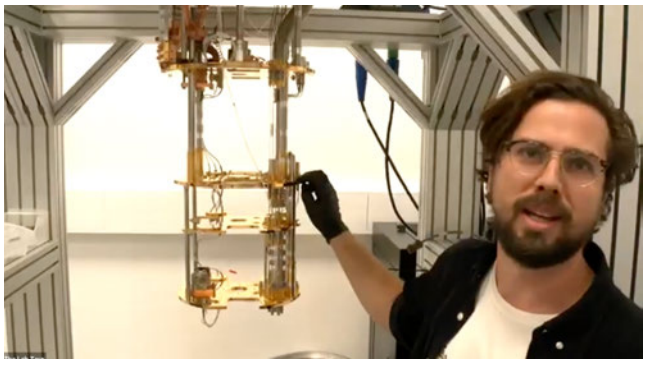
"I loved being able to learn non-high-school science stuff from people that dedicate their lives to science ... But my absolute favourite part was being with people that were just as interested in science as I am."

"Despite us not being able to be with each other, the amazing people organising it made it feel really like a very social and supportive program — I met and heard from some really interesting people."

"Meeting so many smart and unique people who are actually interested in science like I am was eye opening. I now have a large network of people who I feel like I can come to for help when I need it, as well as a broader knowledge of science topics I didn't know existed.

The science side of the program was way beyond my expectations, however it was definitely the collective aspect of solving problems with group members and interacting with the staff that made my ISS so memorable!"

BELOW: Taking a tour around the Quantum Systems lab



School Prizes
Sponsored by the Physics Foundation

Each year the School of Physics awards scholarship prizes to recognise excellence and contributions from our top students. The Foundation proudly sponsors six of these awards. Please join us in congratulating these exceptional students.

ABOVE: The Prize Night started with a Q&A hosted by Ms Vivienne Reiner (far right to left) with Dr Ken Wessen, Dr Caitlin Fisher and Prof Tim Bedding.

In 1981 , the Science Foundation for Physics (the former name for the Physics Foundation) established four undergraduate scholarships to recognise excellence in and encourage the further study of Physics within the University. The title of these scholarships was changed in 2012 to reflect the change in name to The University of Sydney Physics Foundation.

The University of Sydney Physics Foundation Scholarships No I – Junior

Awards are provided on the recommendation of the Head of the School of Physics for proficiency in Junior (first year) Physics, provided that the student's work is of sufficient merit and that the student enrols in at least 12 credit points of Intermediate Physics.

First Year Winners (Junior) – $700 each

- Hon Kwan Chan
- Nash Alexander Hawkins
- Jiayuan Huang
- Ronan David Alfred Potts
- Jim Mussared
- Amelie Francesca Jess Skelton
- Andrew Zhiyang Zhou

Science Foundation for Physics Scholarship No II – Intermediate

Up to five scholarships are to be awarded annually on the recommendation of the Head of the School of Physics for proficiency in Intermediate Physics, provided that the student's work is of sufficient merit

and that the student enrols in 12 credit points of Senior Physics

Second Year Winners (Intermediate) - $800 each

- Patrick Honnery Cahill
- Jake Edelman
- Jadon Yunzheng Lin
- Judd Eli Katz
- Alexander James Morton
- Eben Hugh Taylor

Science Foundation for Physics Scholarship No III - Senior

Up to five scholarships are to be awarded annually on the recommendation of the Head of the School of Physics for proficiency in **Senior Physics**, provided that the student's work is of sufficient merit and that the student enrols in Physics Honours.

Third Year Winners (Senior) - $3,000 each

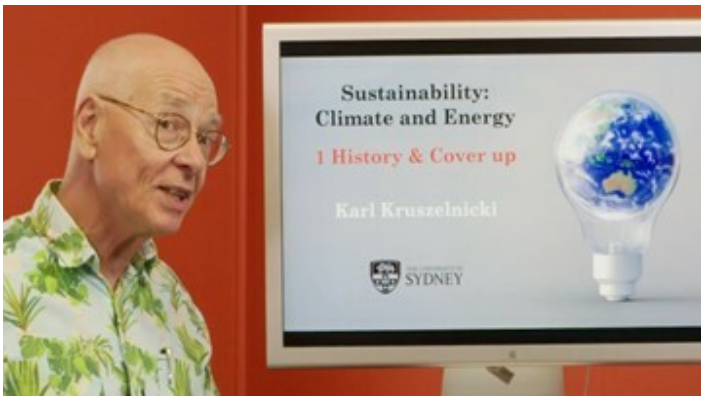
- Michael Sacks
- Jonathan Henry Skelton
- Karl Smith
- Hugo Stackhouse
- Evan Xie

ABOVE: The School Prize Night was opened by Head of School Prof Céline Boehm remarking on the high calibre of student talent within the School .

BELOW: Some of the brightest stars were recognised for their hard work with scholarships sponsored by the Foundation.

Julius Sumner Miller Fellow
Dr Karl Kruszelnicki AM

The 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 the universe through science, inspiring countless students and engaging the general public across a multitude of platforms.



ABOVE: Dr Karl ran a five-part lecture series for a first-year class in the Open Learning Environment Unit Sustainability: Climate and Energy

ABOVE: Dr Karl in infrared as Prof Peter Tuthill illustrates the detection of CO2.

University of Sydney Events

Dr Karl gave two guest lectures for the Leadership in STEMM subjects (Science, technology, engineering, mathematics, and medicine) for students in the University's high-achievers Dalyell stream, inspiring the students with the wonder of science plus messages of good hope and Q&A.

Dr Karl's Sydney Science Forum at Seymour Centre was bustling again with a live audience and endless questions from the kids during the Q&A.

Karl spread the joy of science in his 'Dr Karl's House Party' zoom for over 100 International Science School students.

Karl's five-part lecture series for a first-year class in the Open Learning Environment Unit Sustainability: Climate and Energy again attracted a huge enrolment from students. The unit is now given twice annually, already 425 students have enrolled and it has received ratings over 4 (out of 5) on the Unit of Study Survey. Dr Karl's lectures are reported by many students as being the best aspect in this unit of study 'his videos were amazing!', 'please include more of him!' Karl was also awarded a University of Sydney Learning and Teaching Award for Outstanding Educational Engagement and Innovation for his lectures in this OLE.

Karl's collaboration with Professor Peter Tuthill from Physics continues to offer new opportunities. Their 2021 Plenary Presentation for the Astronomical Society of Australia on climate change from an astronomer's perspective was adapted for a sell-out Sydney Ideas talk in September 2022 at the Charles Perkins Centre. An explanation of the latest data from the James Webb Space Telescope was also included to an enthralled audience. Peter's experiment illustrating C02 was a highlight and showed Dr Karl in infrared!

National Science Week

Karl started National Science Week one week earlier in Tasmania, giving a public talk in Hobart before joining a road trip with scientists and a travelling audience to enjoy science talks and learn about the local flora and fauna. He visited Rosebery District High School to give a Future Careers in Science talk and take questions from the eager students.

Sydney Science Week kicked off with a talk for the primary students (and thrilled principal!) of Glebe Public School at the Chau Chak Wing Museum. Collaborating with University of Sydney staff across disciplines and campus venues enriches both the culture of the campus and offers more science outreach opportunities. Throughout the week Karl

appeared on Sydney Science's social channels as part of the pre-recorded 'Ask an Expert' campaign. Karl continued to build on his relationship with government bodies, the NSW Department of Education hosting Karl for a Zoom Q&A for students all around the state. Karl did an additional three Q&As with schools around Australia, including Bulli High School running a Multiverse Challenge for Science Week. Covid forced the postponement of Karl's three Comedy shows at The Comedy Store and lecture at University of Newcastle, but all went ahead a few weeks later to great success.

Schools

School science Q&As continued every week. Karl chatted with 75 schools (including in England) across three different platforms. The schools often follow up with emails, cards, and drawings of thanks: 'the students were very excited to be part of such a special event, and we're sure Dr Karl's answers sparked many interesting conversations between students, staff and parents at home'. Karl also did a Q&A with the science centre Scitech in Western Australia.

Karl makes every effort to visit schools when he is in the area. He gave a talk about Careers in Science for Randwick Girls, a fun Q&A for Highgate Primary in Perth, and a presentation for Willeton High School in Western Australia.

Eureka School Prize

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

Television

As with all his media appearances, Karl is introduced as Dr Karl from the University of Sydney.
Karl appeared on Sunrise, The Today Show, and The Project, to explain science topics of the day. He was invited to appear on SBS' Celebrity Letters and Numbers to bring his science and maths knowledge into the program's equation.

The ABC network celebrates its 90th year in 2022 and Karl helped celebrate this milestone by appearing on TV and radio segments including a live cross from the Australian Antarctic Division in Hobart.

Radio

Karl's weekly five hours of national ABC science radio segments and CHAI FM in South Africa continued throughout 2022. 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 keeps engaging the public in science, followers now reaching half a million. He won an ACCTA Award (Australian Academy of Cinema and Television Arts) for his TikTok video on Daddy Long Legs.

Karl's social media followers continue to grow with Facebook numbers now 175K. Instagram followers are up to 108K and Twitter now sits at 345K.

Karl's website, drkarl.com is the go-to hub of all things Karl. This year a 'Climate Change' menu has been added with resources dating back from 1981 when Karl wrote his first story on Climate Change.

BELOW: Little scientists from Highgate Primary ask Dr Karl their science questions.

BELOW: Dr Karl won an ACCTA Award for his TikTok video on Daddy Long Legs.

Overseas Activities

In April, Karl gave a livestreamed talk for The Royal Institution in London. In October Karl represented the University of Sydney in a whirlwind speaking tour of London and Lithuania. His UK visit included presentations for The New Scientist and The Royal Institution before travelling to Vilnius to give a workshop on the secrets of science communication for the Lithuanian Journalism Centre.

ABOVE: Dr Karl won an ACCTA Award for his TikTok video on Daddy Long Legs.

Podcasts

Dr Karl's two ABC podcasts and weekly University of Sydney podcast 'Shirtloads of Science' (average download per episode is 20K) continue to thrive. Shirtloads featured more University of Sydney academics across disciplines including a two-parter with virologist Professor Eddie Holmes on the evolving situation with the COVID pandemic. This podcast attracted international attention from a German TV station quoting 'I thought your argument was the best and most convincing I have heard so far. You were able to explain to the listeners why there is enough evidence today that the virus originated at the Wuhan market. Thank you.'

Karl also interviewed Professor Geraint Lewis on all things cosmology (including an episode on the James Webb Space Telescope, giving a deep insight into its capabilities and astounding images); a three-part series with astrophysicist Professor Tara Murphy, forensic psychology with Associate Professor Helen Paterson, quantum computing with Professor David Reilly, dietetics with Dr Nick Fuller, and urban ecology with Professor Dieter Hochuli. Karl also interviewed international science authors Brian Greene and Johann Hari.

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 stories for his 48th book – a long-awaited autobiography.

Festivals and Conferences

Festivals are an opportunity to bring science and the University of Sydney flag to different audiences. Karl presented a Great Moments in Science Talk at the Falls Creek Festival in February amongst the art, comedy, and music celebrations. The World Science Festival in Brisbane was cancelled due to the floods although the variety game event Night of the Nerds went ahead a few months later. Karl was able to zoom with regional teachers for a Q&A.

Thankfully Karl was able to attend the regional event in Gladstone for Q&A with three local schools and a science comedy show.

Karl celebrated the end of 2022 at the Lost Paradise Festival in the Glenworth Valley where he gave a presentation and was a panellist with Greenpeace and indigenous ecologists talking about the environment.

This year Karl was part of a mentoring team for scientists performing as The Steam Room for the Sydney Comedy Festival. He joined a comedian and drama improvisation teachers to train up a group of scientists to deliver a 5-minute science-comedy-stand-up routine. Karl also performed during the festival and was so successful that he performed three more science comedy shows at The Comedy Store in September. Reaching a new audience through science comedy has been a highlight of the year.

Splendour (in the mud this year) welcomed Karl give a solo show featuring the facts about the Tongan volcano and finding scientific truth in today's fake news climate. The NSW Department of Education invited Karl back for a space-themed Q&A as part of the Australian Virtual Astronaut Challenge.

Mentoring and Media/Speaker Training

Karl kicked off 2022 by presenting a fun, online science session for 600 Year 12 students attending the National

Youth Science Forum. He zoomed with a Professor from the University of Tokyo keen to learn more about carving a career in science communication.

Karl was invited by Inspiring Tasmania to give a Science Communication workshop for STEM professionals and PhD candidates.

Karl continues to meet with University of Sydney aerospace engineering student Riley Havela to offer support and guidance with her studies and career pathway.

Karl was again involved in the ABC ‘Top 5 Under 35’ program which supports early science career researchers. The group spend a day at the ABC for some training and a science communication session with Dr Karl.

As well as mentoring science students to deliver comedy sets, Karl continues to support students from the University of Sydney. Now that students are back on campus, they come by the office to ask for a selfie or study and career advice. Karl also supports academics with their science communication skills, and professional staff with audio and visual technical questions regarding science communication. Dr Karl looks forward to continuing his mentorship and dynamic dissemination of science throughout 2023.

ABOVE: Dr Karl was part of a mentoring team for some budding science-comedians at The Sydney Comedy Festival reaching a new audience with science.

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
- President, Mr Michael Winternitz Appointment term: 2021 AGM Meetings attended: 3
- Deputy President, Mr James Kirby Appointment term: 2021 AGM Meetings attended: 3
- Professor Iain Young, Dean, University Officer Meetings attended: 0

Members
- Professor Céline Boehm (Ex-officio Head of School) Meetings attended: 3
- Dr Gregory Clark AC FTSE FAA FAPS Meetings attended: 3
- Mr Trevor Danos AM FTSE (Observer) Meetings attended: 2
- Professor Gemma Figtree AM FRACP, FCSANZ, FAHA Meetings attended: 1
- Professor Gregory McRae (Overseas Member) Meetings attended: 3
- Emeritus Professor Anne Green AM FTSE FRSN FAIP FASA Meetings attended: 2
- Dr David Mills AM Meetings attended: 1
- Professor Lawrence Cram AM Meetings attended: 1
- Emeritus Professor Richard Collins FTSE - Meetings attended: 1
- Emeritus Professor Max Brennan AO FAA – Meetings attended: 1
- Associate Professor Robert Hewitt – Meetings attended: 3
- Professor Philip Gale, Interim Dean of Science - Meetings attended: 1

Council members were elected at the Foundation's AGM on 4 March 2021. 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 2021: 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, & 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.

THE UNIVERSITY OF SYDNEY

Annexure 1

TO: **Financial Control and Treasury**

FROM: **University Officer (Foundation)**

DATE:

SUBJECT: **Certificate of Operations**

CERTIFICATION

I hereby certify that the activities reflected in the Financial Statements for the year ended 31 December 2022 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.

Prof. Marcel Dinger
Dean, Faculty of Science

Signature
University Officer (Foundation)

Name (Please Print)

Date: 10 February 2023

The University of Sydney

Uni of Syd Physics Foundation (L7500_SCI_FND_PHYS)

Balance Sheet

as at 31 December Calendar Year 2022

	Note	31 December CY2022	31 December CY2021
ASSETS			
CURRENT ASSETS			
Short Term Funds	3	546,525	975,745
Total Current Assets		**546,525**	**975,745**
NON CURRENT ASSETS			
Medium/Long Term Investments	3	33,834,275	33,990,572
Total Non Current Assets		**33,834,275**	**33,990,572**
TOTAL ASSETS		**34,380,799**	**34,966,317**
LIABILITIES			
CURRENT LIABILITIES			
NON CURRENT LIABILITIES			
NET ASSETS		**34,380,799**	**34,966,317**
EQUITY			
Accumulated Funds		34,380,799	34,966,317
TOTAL EQUITY		**34,380,799**	**34,966,317**

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 $7,227,548 of the Messel Endowment ($7,096,220 in 2021) managed by the University of Sydney to retain its value in accordance with the commitments made by the Foundation when the Endowment was established.

The University of Sydney

Uni of Syd Physics Foundation (L7500_SCI_FND_PHYS)

Income Statement

for the Period Ended 31 December 2022

	Note	31 December CY2022	31 December CY2021
INCOME			
Grants		0	0
Scholarships, Donations and Bequests		1,550	6,601
Business and Investment Income		21,320	6,746
Realised Gain / (Loss) on Investments		625,310	5,591,999
Investment Administration Fee		(115,972)	(77,371)
Internal and Other Income		12,000	14,500
Total Income		**544,208**	**5,542,475**
EXPENDITURE			
Salaries	4	949,662	658,474
Consumables		3,103	20,275
Equipment and Repairs/Maintenance	5	14,184	179,995
Physics Grand Challenges Seed Funding		2,050	500,000
Services and Utilities		8,417	8,863
Travel, Conferences, Entertainment		9,148	0
Consultants and Contractors		8,564	0
Student Costs and Scholarships		34,864	21,803
Other expenses	6	414,995	324,557
Total Expenditure		**1,444,986**	**1,713,967**
Surplus / (Deficit)		**(900,778)**	**3,828,508**
Accumulated Funds		34,966,317	30,966,889
Accumulated Funds Adjustments		315,261	170,921
Total Accumulated Funds		**34,380,799**	**34,966,317**

Notes to Financial Statements (….continued)

4. The 2022 salary expenditure of $950k includes $209k of ISS-related salary expenses and $609k of education related funding support for the salaries of ten School of Physics staff members.

5. The Equipment and Repairs/Maintenance expenses totalling ~$14k are, predominantly, various teaching/research items paid from the $1.5m annual Foundation funds approved by the Dean and Foundation Council to be utilised by the School to support its various teaching- and research-related initiatives (see Note 4 above for further information).

6. "Other expenses" totalling $415k in 2022 includes $373,233 of CCA overhead charges, which are automatically debited against all University accounts (including Physics Foundation) based on staff numbers and other cost drivers. Consistent with the accounting treatment of previous years the 2022 CCA of $373,233 will be adjusted in the 2023 accounts.

Therefore the 2022 total direct expenses excluding CCA are $1,071,753 and the adjusted Accumulated Funds as at 1 January 2023 will amount to $34,754,032.

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.

Tracie Sillers
Associate Director Finance
Faculty of Science

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

For more Information
Contact Us
physics.foundation@sydney.edu.au
sydney.edu.au/science/schools/school-of-physics/physics-foundation.html

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