The University of Sydney Physics Foundation

THE UNIVERSITY OF SYDNEY

Annual Report 2024

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 title: The Eyes of a Detector

This photograph shows part of a photomultiplier tube (light detector) array behind a thin wire mesh.

These photomultiplier tubes are the eyes of the LUX-ZEPLIN (LZ) experiment, looking to detect faint light signals from the rare interaction of dark matter particles.

LZ is trying to solve the long-standing mystery of the nature of dark matter.

The experiment is filled with 7 tonnes of liquid xenon, which would emit light when a dark matter particle scatters off a xenon nucleus.

Unfortunately, radiation from the environment can cause very similar signals. That's why the experiment is well shielded, 1.5 km under the Earth's surface in an old goldmine in South Dakota, US.

Who knows, maybe one day, the photomultiplier tubes in this picture will spot the first evidence of a dark matter particle interacting in the detector.

Theresa Fruth

Digital Photography by Matt Kapust, Sanford Underground Research Facility, 2023.

The University of Sydney Physics Foundation

Annual Report

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"My greatest achievement has been the ISS and I hope it continues in perpetuity"

Professor Harry Messel AC CBE

President's Report

Michael Winternitz

It is my pleasure to report upon the Physics Foundation's continued support of the School of Physics throughout 2024.

We have an exceptionally proud history of supporting the School of Physics for over seventy years, through a variety of initiatives, whereby we have contributed over $100 million in funding.

In 2024, the Physics Foundation provided approximately $1.5 million in funding to the School of Physics through a variety of initiatives, including the newly founded Physics Foundation Scholarship scheme. In addition, we continued with our support of several specialised staff positions, Physics Grand Challenges, academic prizes, the Professor Harry Messel International Science School, amongst other support.

The Physics Foundation Scholarship scheme is a new multi-million dollar initiative that is financially supported and made possible by the Physics Foundation, in conjunction with the Faculty of Science.

It is aimed at attracting ultra-high performing international post graduate students to the School. We hope that the program will build a cohort of high impact researchers over several years, supporting the School's efforts in maintaining its prestigious record of being amongst the top Physics research institutions in Australia.

Pleasingly, this initiative attracted significant interest, and four international students were awarded scholarships in its inaugural year. At the time of writing this report a further four have been awarded for 2025.

We continue to provide significant financial support for a total of six specialised positions within the School, including Dr Theresa Fruth, an experimentalist in Astroparticle Physics and an expert in Dark Matter direct detection.

Professor Maryanne Large is an experimental scientist with expertise in optics and materials science. She is best known for her work on developing microstructured polymer optical fibres. She is also interested in the translation of research to applications with real-world impact and works to show students how physics can be applied in areas outside of academia.

The Foundation also supports the position held by Associate Professor Bruce Yabsley, who is a world-renowned and highly cited experimental particle physicist. Professor Yabsley previously held a Future Fellowship from the Australian Research Council and was one of the Chief Investigators of the Centre of Excellence for Particle Physics at the Terascale (CoEPP).

It was an absolute pleasure to award numerous Foundation supported academic prizes to a range of students from the School, a welcome reminder of the diverse talent and pursuit of academic excellence that continues to breathe within the sandstone walls of the School.

Our longest standing initiative is the Professor Harry Messel International Science School, which is held biennially and attracts around 100 talented high school students around the world and across Australia, for a two week experience at the University of Sydney.

During the ISS, students are immersed, challenged and hear from some of the world's best scientific minds, alongside attending a range of networking and social events - an experience that has proven life-changing for so many. We look forward to welcoming what will no doubt be yet another talented cohort in July 2025.

Pleasingly, the Physics Foundation is well positioned to support the ISS and many other important initiatives into the future, underpinned by its strong financial position. This is largely due to significant fundraising efforts over decades by the Physics Foundation, and importantly careful management of funds raised, which enables us to consistently support the ISS and School every year.

I would urge you to consider donating to the Messel Endowment to support the ISS and our efforts to ensure it can run in perpetuity.

After nearly a decade of being on the Physics Foundation as a Council member, I am truly honoured to have been involved, I would like to thank current and previous Council members, and in particular Deputy President James Kirby for their support and guidance, and the Dean and Head of School for their leadership of such a world-class School.

I will most certainly remain a steadfast supporter and keen observer for decades to come.

Michael Winternitz
President - Physics Foundation

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 original purpose of 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
- 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 2024, the Endowment holds $7,392,031 in funds. During 2024, donations and bequests to the Foundation totalled around $15,000.

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

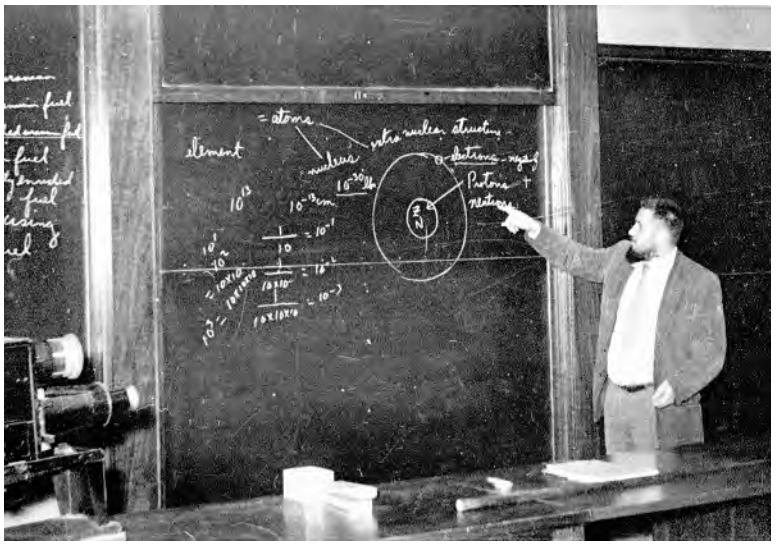


Image: Professor Harry Messel Teaching, Courtesy of the University of Sydney Archives, [REF-00050555].

The University of Sydney Physics Foundation
Members 2024

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)
- 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 AC FTSE, FRSN, FAIP, FASA (2017)
- Mr Michael Winternitz (2021)

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)
- Professor Tara Murphy (2023)

Foundation Council 2024

Office Bearers of the Foundation

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

University Officer

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

Council Members

- Mr Paul Chadwick
- Emeritus Professor Lawrence Cram AM
- Professor Gemma Figtree AM FRACP FCSANZ FAHA
- Mr James R Kirby
- Mr James Read
- Mr Michael Winternitz

University Ex Officio Council Members

- Ms Alexia Nicholson

Foundation Members

Founder

- Emeritus Professor Harry Messel AC CBE

Life Governors

- Dr Gregory Clark AC FTSE FAA FAPS
- Mrs Louise Davis AM
- Emeritus Professor Anne Green AC FTSE FRSN FAIP FASA
- Associate Professor Robert Hewitt
- Professor Greg McRae
- 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
- Emeritus Professor Lawrence Cram AM
- Mr Raymond Kirby AO

Corporate Members

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

Head of School Report

Professor Tara Murphy

Despite the continued uncertainty brought about by external factors, both in the Australian higher education sector, and the wider geopolitical situation, I am happy to report that the School of Physics has had an outstanding year. At the end of 2024 we had an external review of the School, conducted by the Faculty of Science, and the external panel report was very positive. To quote:

"The School of Physics is a well operating and successful School. The legacy of this long-standing School is well served by its current leadership and staff corpus. The School is well-regarded for its Research and Education quality. Research outputs in astronomy, astrophysics, photonics, quantum physics, sustainability, and medical physics are areas of noted excellence. Participation in state-of-the-art multidisciplinary centres has seen research publications boom and the School boasts substantial grant and gift income. The School is attractive to both domestic and international students and performs well regarding student experience: Undergraduate students regularly place the School well above University and Faculty's averages and a majority of HDR students are on scholarships and progress into careers as field leaders and industry players, often returning to engage with the School in business collaboration and student engagement."

I am very proud of all of our staff and students, and it is great to see our School's achievements recognised in this way.

Of course, a critical part of the legacy mentioned by the panel, is the role of the Foundation. 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. Our current major initiative is the Physics Foundation Scholarship scheme. The aim of the scheme is to attract 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.

We now have eight scholars who have started their PhDs in the scheme. This is a diverse group of students, from Bolivia, Canada, China, India, Italy and Mexico. These 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. You can read more about some of them in this year's annual report.

Next time you have the opportunity to visit the School, you might take time to read the beautiful new posters we have put up, that tell the story of education and outreach activities in the School over the past 100 years. The International Science School, and associated efforts, are of course a big part of this story. ISS 2025 will run in July 2025, bringing together over 100 outstanding science students from around Australia and the rest of the world. We are looking forward to welcoming them all to our wonderful campus and academic community.

Specialised Staff Supported by the Physics Foundation

Academic Profiles

The Physics Foundation promotes excellence in research and teaching by supporting a number of outstanding academic staff members.

Dr Theresa Fruth is an experimentalist in Astroparticle Physics and an expert in Dark Matter direct detection. She joined the University of Sydney as a lecturer in October 2022.

Theresa received her DPhil from the University of Oxford in 2019 following her work on monitoring sensors and PMT studies for the LUX-ZEPLIN (LZ) dark matter search. She continued her research on the LZ experiment as a post-doctoral researcher at University College London (UCL), contributing to the commissioning and first science exploitation of the detector. At Sydney, she has also joined the Australian SABRE South collaboration, which will be the first experiment of its type in the Southern Hemisphere.

Theresa is leading the Australian effort towards XLZD, a future global dark matter experiment using liquid xenon as a target medium. At the same time, she is establishing a Dark Matter R&D laboratory in the School of Physics with her colleague Laura Manenti.

Theresa was awarded the Physics Seed Funding scheme to build the first setup in the lab intended to test photosensors. Beyond the search for dark matter, Theresa is part of the Homeward Bound leadership program for women in STEM and voyaged to Antarctica in early 2025 as part of this initiative.

2024 Highlights

2024 was an exciting year, as the LZ experiment published world-leading dark matter limits from its latest data-taking campaign. While there was no evidence of dark matter interacting in the detector, the results show that the detector is the best available instrument to explore dark matter candidates heavier than the proton over the next years (Theresa's The Conversation article on the topic).

At the end of 2024, Theresa was elected to the newly formed XLZD Executive Board.

Image:Dr Theresa Fruth

Professor Maryanne Large is an experimental scientist with expertise in optics and materials science. She is best known for her work on developing microstructured polymer optical fibres, and more generally in fabricating specialty fibres. The technology developed by Professor Large has been used in vastly different applications such as a novel gas sensor (based on a fibre Bragg grating) and as a flexible bioscaffold for stem cell-growth. Her expertise in producing structures in fibres from unusual materials will soon be applied to one of the 2023 Physics Grand Challenges winning projects *Nanostructured textiles for a sustainable warming world*.

Professor Large is also interested in the translation of research to applications with real-world impact and works to show students how physics can be applied in areas outside of academia.

2024 Highlights

Professor Large's research group experimentally demonstrated the novel optical sensor for detecting methane, a major greenhouse gas. This has led to a new funding and collaboration with the Food Agility CRC for monitoring methane emission from cattle.

Professor Large developed a new third year course *Sustainable Innovation* which ran for the first time in 2024. The unit supports the new Sustainability Major (run by the Science faculty) and is also an option for the Innovation and Entrepreneurship major. The unit was very well received by students.

Associate Professor Bruce Yabsley is an experimental particle physicist. His past work includes an accelerator-based neutrino experiment, searches for exotic quarkonium-like mesons at the LHC, and a wide range of physics topics at electron-positron colliders. Professor Yabsley previously held a Future Fellowship from the Australian Research Council, and was one of the Chief Investigators of the Centre of Excellence for Particle Physics at the Terascale (CoEPP). His current research is focused on searches for rare particle decays at the Belle II experiment in Japan.

2024 Highlights

In 2024 Associate Professor Yabsley was shortlisted for the roles of spokesperson (i.e. chief executive) and physics coordinator for the Belle II experimental collaboration, reflecting the Sydney group's contribution to Belle II.

The publication of Belle II's paper on "Evidence for B+ -> K+ nu nubar decays", https://doi.org/10.1103/PhysRevD.109.112006, is their most important result to date. The observed rate is significantly above the standard model prediction, and both related and follow-up measurements are being closely watched.

His student, Priyanka Cheema, submitted her PhD thesis on development of a rare decay search at Belle II in late 2024. The thesis passed examination and they expect to publish a paper on this work in 2025.

Top Image: Professor Maryanne Large standing next to the polymer fibre draw tower. Bottom Image: Associate Professor Bruce Yabsley.

Messel Fellowship
Academic Profiles

The Professor Harry Messel Fellowship offers a high-profile position in the School of Physics to top female researchers. The Messel Fellow undertakes independent research that strengthens and/or complements existing programs in the School.

Dr. Stefania Barsanti is an astrophysicist specialising in galaxy evolution. She has published extensively on the impact of the local and large-scale cosmic environments on galaxy properties, using optical photometric, spectroscopic and spatially-resolved spectroscopic data.

Her most significant discovery is the detection of preferential directions for the spin of galaxies in cosmic filaments according to the stellar mass in their central regions, revealing different galaxy formation pathways.

She is the principal investigator of the MAGPI galaxy redshift survey, a founder of the Hector galaxy survey and a member of the 4HS galaxy survey, covering several leadership positions within these teams.

Since November 2024, she is a Messel Research Fellow at The University of Sydney, working at the Sydney Institute for Astronomy. Previously, she was an ASTRO 3D Postdoctoral Fellow at the Australian National University.

She received her PhD from Macquarie University in June 2021. Before Australia, she studied physics, astronomy and cosmology in Italy.

2024 Highlights

During 2024, Dr. Stefania Barsanti was featured as a Spotlight Member for the ASTRO 3D Centre of Excellence annual report to the Australian Research Council. She was also an invited speaker presenting her research at “The co-evolution of galaxies and their large-scale environment" conference in China and at the “Anglo-Australian 50th Anniversary” symposium at Siding Spring Observatory

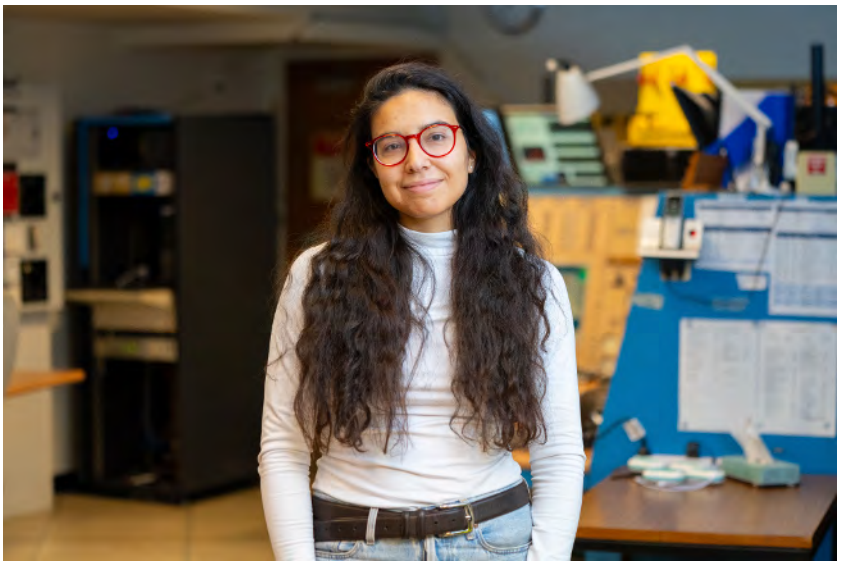


Image: Messel Fellow - Dr Stefania Barsanti

Dr. May G. Pedersen graduated with a bachelor's in physics and masters in astronomy at Aarhus University (Denmark) in 2016. The same year she moved to Belgium to do a PhD at KU Leuven to study and model the pulsations of Slowly Pulsating B stars, which are three to eight times as massive as the Sun, using data from the Kepler space telescope.

She defended her PhD in 2020 and published the results of her thesis in Nature Astronomy in 2021, demonstrating for the first time the diversity of mixing taking place in the interiors of Slowly Pulsating B stars, which critically impact the future evolution of these stars.

In September 2020, Dr. May G. Pedersen moved to California to take up a postdoc at the Kavli Institute for Theoretical Physics at UCSB. During her time there she started studying the pulsations of massive stars observed by the TESS space telescope and was awarded competitive funding for her research through NASA's TESS Guest Investigator program.

As of December 2022, Dr. May G. Pedersen has been a Professor Harry Messel Research Fellow at the School of Physics University of Sydney, where her current focus is on the study and modelling of pulsating massive stars in OB associations.

2024 Highlights

Dr May was awarded the highly competitive Discovery Early Career Researcher Award from the Australian Research Council to be commenced in December 2025.

She organized and ran the first Australian MESA school, called MESA Down Under, focusing on teaching the participants how to use the open-source stellar structure and evolution code MESA.

Image: Messel Fellow - Dr May G Pedersen

100 Years School of Physics Building
Alumni Event

2024 marked 100 years since the completion of the School of Physics Building. The School held a special event to celebrate its achievements over the past hundred years and showcase what it has to offer today.

The event was generously supported by the Physics Foundation.

In March 2024, the School of Physics held an event to mark the 100-year Anniversary of The School of Physics Building, and the 70th Anniversary of The University of Sydney Physics Foundation.

The aim of the event was to reconnect with School alumni, celebrate the achievements of the School over the past 100 years and to promote current research and education looking toward the next 100 years.

The event was held on the 21st of March and consisted of building tours, a formal dinner and interactive presentations for 100 distinguished guests. Attendees included School Alumni, former Heads of School, School staff, HDR students, Physics Foundation Council Members and Industry Partners.

The event was MC-ed by former ABC presenter, Bernie Hobbs. The Head of School, Professor Tara Murphy, welcomed the guests with an opening introduction to the School. The President of the Physics Foundation Mr Michael Winternitz gave an important speech on the relationship between the School and the Physics Foundation noting the many initiatives that have been funded over the past 70 years.

Other speakers included Professor Tim Bedding (former Head of School), Professor Anita Ho-Baillie, Dr Derek Muller (Alumni) and HDR students Sophie Cottam and Kovi Rose who spoke about the history of the School, their research and their experience and connections with the School.

Image: The School of Physics Building, University of Sydney Archives [REF-00091879]

Building tours were a popular activity with School Staff members, Professor John O'Byrne, Professor Maryanne Large, Professor Chris Betters and Professor Simon Fleming organising and acting as guides on the night.

A highlight of the evening was a guessing challenge organised by School Staff and Professor Andrew Doherty that had attendees compete to guess the function of some of the historical scientific equipment that has been used in the School over the past 100 years.

The School held additional activities to celebrate the 100 year milestone, showcase the School's research and facilities, reconnect with high-profile alumni, industry partners, and philanthropists, and to attract new students and partners. A Physics Showcase, consisting of facilities tours and research presentations, was held on the 20th of June 2024.

The 100 year School of Physics Building event was a great success, and the School received positive feedback by all who attended.

Most notable was a generous donation of a historical painting of the Physics Building by the Vonwiller's family, reflecting the importance of maintaining connections with all stakeholders and promoting and celebrating the outstanding achievements in teaching and research at the School of Physics.

Top Image: Professor Andrew Doherty talks about the history of the School of Physics Building. Bottom Image: Professor Maryanne Large gives a building tour.

School of Physics
Prize Night

The School of Physics Prize Night celebrates outstanding students from the School of Physics. The Physics Foundation supports a number of awards reflecting one of our core objectives - to promote excellence in education within the School of Physics.

The School of Physics Prize Night was held on the 19th of September. President Mr Michael Winternitz attended the ceremony to present the Physics Foundation Awards to outstanding students across the School.

The occasional address was given by Henry Bilinsky who is the founder and CEO of MicroTau, an advanced manufacturing and clean aviation technology company.

Henry spoke about MicroTau's mission to improve the efficiency of the global aviation fleet through an aircraft modification package that mimics the drag-reducing microstructures found in shark skin.

The technology enhances efficiency by 4%, which can save up to US$8 billion in fuel and reduce CO_2 emissions by 40 million tonnes annually.

Henry holds an Honours degree in Advanced Physics (2010) and a Juris Doctor of Laws (2014) from the University of Sydney.

Physics Foundation Awards

Physics Foundation Prize for Junior Physics

- Wentao Jing
- Roger Lin
- Jude Luca Metcalf
- Sean Michael O'Gorman
- Oliver Sacks

Awarded to the top students in Junior Physics who have enrolled in Intermediate Physics.

Physics Foundation Prize for Intermediate Physics

- Daniel Bruwel
- Caleb Clark
- Milo Langker
- Austin Lin
- Priya Mehta

Awarded to the top students in Intermediate Physics who have enrolled in Senior Physics.

Physics Foundation Prize for Senior Physics

- Hon Chan
- Andrew Li
- Nihar Makadia
- Amelie Read
- Angus Rutherford

Awarded to the top students in Senior Physics who have enrolled in Physics Honours.

Physics Foundation Prize for Excellence in Junior Groupwork

Mainstream

- Eve Gasser
- Max Holstegge
- Sarah Shaddock

Advanced

- Alexander Ewers
- Tim Lau
- Alex Noot

Awarded to two groups of students, one from Mainstream and one from Advanced Junior Physics based on overall performance in groupwork.

Physics Foundation Prize for Excellence in Senior Groupwork

- Isaac Broadhead
- Amelie Read

Awarded based on overall performance in group work in PHYS3888.

Physics Grand Challenges

Funding Research

Driving excellence in physics and interdisciplinary science research and teaching.

In 2019, The Physics Grand Challenges was conceived by then Head of School, Professor Celine Boehm, to fund ground-breaking research projects.

Funded by the Physics Foundation, the Physics Grand Challenges are a 5-year initiative, with the aim of supporting unconventional, innovative and interdisciplinary projects that would typically struggle to attract conventional funding.

Winning teams received up to $250,000 toward their project to be used over a two year period.

To date, the Physics Foundation has funded over $3 million worth of Physics Grand Challenges projects whose research ranges across fields from space, medicine and the environment.

For more information and to read about past winning projects, see the Physics Grand Challenges webpage.

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

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. X-rays with different photon energies have different penetration powers and thus have different applications.

Traditional materials for X-ray detectors, such as cadmium tungstate ($CdWO_4$), α-Se, and mercury iodide (HgI_2), 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.

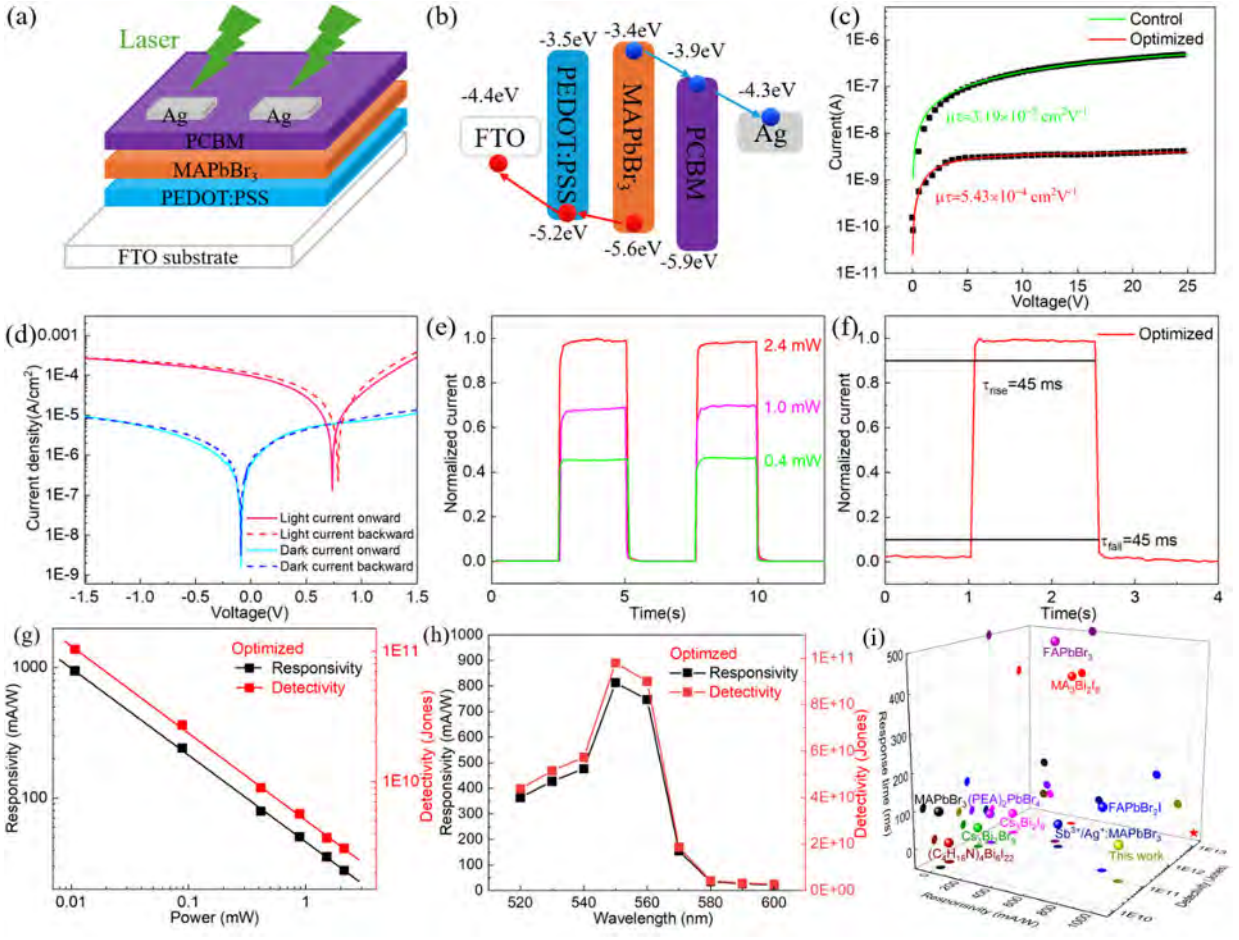


Figure 1. (a) Device structure of highly textured $MAPbBr_3$ photodetector. (b) Energy levels alignment of each material. (c) Bias-dependent photoconductivity of the control and optimized highly textured $MAPbBr_3$. (d) Current density-voltage (J-V) curve of optimized highly textured $MAPbBr_3$ under dark and 0.3 mW/cm² illuminated situations, including the forward and reverse scanning. (e) Transient photocurrent of the optimized highly textured $MAPbBr_3$ photodetector under various laser powers of 2.4 mW, 0.96 mW, and 0.41 mW. (f) Response time of optimized highly textured $MAPbBr_3$ photodetector. (g) Responsivity and detectivity of optimized highly textured $MAPbBr_3$ photodetector under various laser powers with 555 nm wavelength at 5 V bias. (h) Responsivity and detectivity of the optimized device under various laser wavelengths. (i) Comparison of significant detection parameters between this work and other research works, including responsivity, detectivity, and response time.

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 Achievements

Recently, we have demonstrated a straightforward fabrication process for realizing large-area (up to 100 cm^2) and highly textured $MAPbBr_3$ by combining inverse-temperature crystallization (ITC) with a hotpressing process.

Thanks to the following hot-pressing treatment, the obtained perovskite active layers can be effectively integrated into the conductive substrates, facilitating electrical connections and device integration.

The obtained $MAPbBr_3$ exhibits a low trap density of 1.4×10^{11} cm^{-3} and a high carrier mobility of 217 cm^2 V^{-1} s^{-1} (with a mobility-lifetime product of up to 5.4×10^{-4} cm^2 V^{-1}).

The resulting photodiodes show a maximum responsivity of 944 mA W^{-1}, a champion detectivity exceeding 1×10^{11} Jones, and a fast photoresponse of 45 ms, with excellent stability.

This work constitutes a demonstration of large-area single-crystal perovskite photodetectors integrated directly onto substrates and paves the way for various practical applications such as optical imaging technology.

Student Engagement

We 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.

Runkai mastered relevant experimental skills from synthesis to XRD, SEM, RPF, and absorption spectroscopy. More importantly, he has achieved the above mentioned promising results and has a plan in place to further improve the perovskite films.

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

Outcome

Our photodiodes showcase the outstanding device performance including a high responsivity of 944 mA W^{-1}, an optimal detectivity of up to 1×10^{11} Jones, and a fast photodetection speed of 45 ms in the visible regime.

This cost-effective, solution-processed approach enables the fabrication of large-sized single-crystal perovskite photodiodes tailored to match the size of target applications.

These findings pave the way for the integration of perovskite single crystals in a wide range of commercial photodetector applications, combining scalability, affordability, and high performance.

Built on the achievements from this Grand Challenge project, we have applied for the ARC funding. Our application has been assessed quite high and ranked at No. 96, well within the successful 128, but our application has been unsuccessful due to unknown reasons. However, we will continue with our application.

Professor Rongkun Zheng
Project Lead

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, prone to artefacts, and require intensive training.

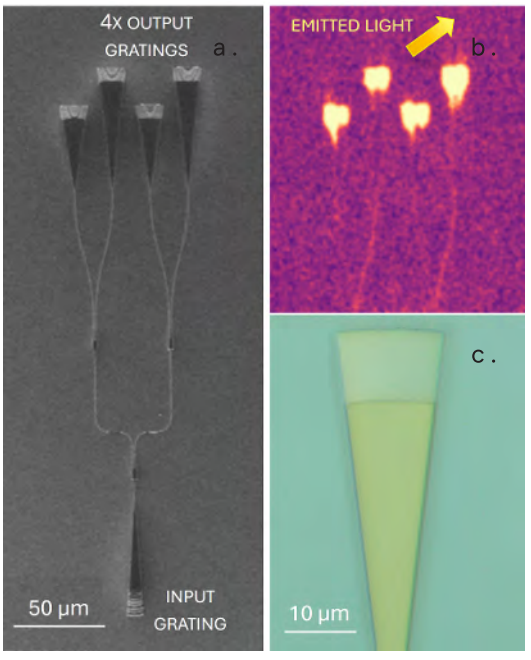
In 2005, a revolutionary field emerged: optogenetics. This involves expressing photoactive proteins in grown neurons to control and detect their electrical activity by light. Most research has been translated into brain implants; only limited research has focused on nerve interfaces.

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 Achievements

Building the Team

- John Scott, with experience in photonics fabrication, testing and modelling joined in September 2023.
- Dr Glena Travis, expert in molecular biology joined in October 2023 .
- Dr Azadeh Mirabedini, with expertise in bioengineering joined in October 2024.
- Dr Hallur Reynisson with expertise in Neurobiology, joined in January 2025 .



Photonics

We fabricated more complicated Si_3N_4 waveguide and grating couplers (Fig. 1c) to be able to illuminate more neurons at the same time by coupling light into one single input (Fig. 1a). Fig. 1b shows that light can be efficiently and homogenously emitted from 4 grating outcouplers, which are receiving light from just one input grating. Furthermore, we have developed and optically tested the fabrication process to manufacture such optical devices on a glass, i.e. transparent, substrate.

These grating outcouplers will be positioned in correspondence of photoactive neurons and able to excite them at will. Fig. 1c shows a Scanning Electron Microscope image of the high-quality fabricated grating coupler.

Figure 1. a) optical image of the test waveguides, showing the input grating (bottom) and the 4 output gratings. b) optical image of light outcoupled from 4 gratings - we use a 500nm wavelength. c) enlarged outcoupling grating.

We have re-designed the site on the chip where each neuron will be located to avoid using two different photonic chips as originally proposed (i.e. one for neurons connected to afferent nerves and one connected to efferent nerves), making it truly bidirectional, i.e. each site will be able to induce and detect neural activity.

Differently from any other photonic brain implant in the literature, where the excitation is optical and the recording is electrical, we are developing an all-optical photonic platform which will interact with neurons bidirectionally by only light illumination and detection.

Two of the key elements to achieve this functionality are: 1. an embedded dichroic mirror, which reflects all the scattered unwanted light and let pass only the wanted fluorescence onto an integrated detector sitting below the mirror; and 2. an integrated photodiode. Both the mirror and the photodiode will be integrated below the site where the neuron is located, under which the respective grating coupler is sitting, i.e. a stack constituted by a neuron on a grating coupler, sitting on the mirror which covers the photodiode. We have successfully designed and fabricated both the mirror and the integrated silicon photodetector.

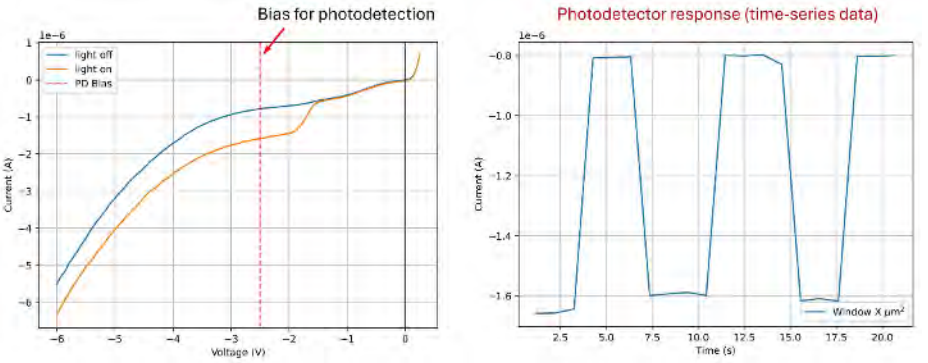


Figure 2. a) Photodetector current-voltage behaviour as a function of light, showing the expected photodiode curve. b) typical current-time photodetector response from our integrated photodiode, showing its high expected performance.

Figure 2 shows the high-performance behaviour expected by our integrated photodiode as a function of light impinging on it. The photodiode's active area was designed to be as large as a neuron body. We have also manufactured larger and smaller photodiodes in case different sizes are needed.

Biology

On the biological side we have selected the most suitable activator/indicator combination that will be used to transduce the neurons, making them optically active. We have grown cortical neurons in vitro from human induced pluripotent stem cells (i-PSC) into mature organoids that are then dissociated into individual connected neurons.

We have selected, after testing, two different combinations, 1. Chronos, as the activator (i.e. induces neural activity if excited by light), and GECO2 as calcium indicator (i.e. exhibits a decrease in fluorescence as a function of a calcium ions concentration, which is indirectly caused by neural activity); 2. Chronos and Archon1, which is a voltage indicator (i.e. exhibits an increase of fluorescence as a function of voltage change directly caused by neural activity). The combo 1 is much slower due to the slower response of ions diffusions, whereas the combo 2 is much faster and directly linked to the neural activity.

We successfully transduced them into cortical neurons and demonstrated their modulation as a consequence of both spontaneous and induced neural activity. Figure 3a shows the presence of the Chronos activator in a network of cortical neurons, whereas Fig. 3c shows the correspondent presence of Archon 1 in the same cells; the induced modulation is effective only when both proteins are present in the same cell. This is clearly shown in Fig. 3b, where the induced modulation is applied by light at a specific wavelength (~500nm) to the cells, and in Fig. 3d, where the respective increase of fluorescence is detected as a consequence of the induced neural activity. The next milestone will be to perform the same test by the chip.

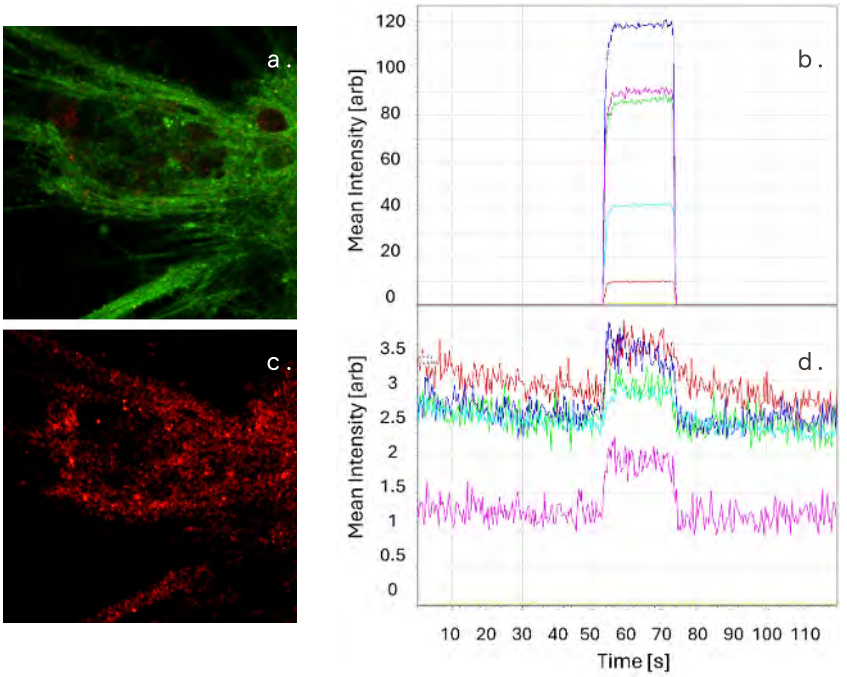


Figure 3. a) Cortical neurons transduced with Chronos. b) light applied to excite Chronos. c) Cortical neurons transduced with Archon1. d) consequent fluorescence increased from Archon1 due to the neural activity induced by Chronos, excited by light.

Associate Professor Stefano Palomba
Project Lead

Physics Grand Challenges 2022/23 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 precision medicine approaches that tailor treatments to an individual's 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. Analogies between concepts in Quantum Theory and time-series machine learning are shown in Figure 1.

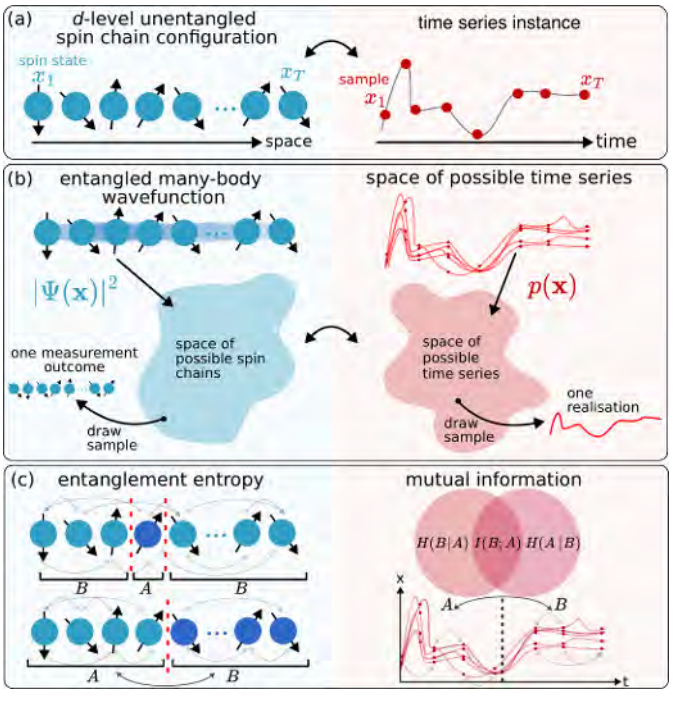


Figure 1. Analogies between quantum theory and time-series machine learning. (a) A single spin configuration is analogous to a single time-series instance. (b) A many-body wavefunction is a vector in a Hilbert space which is the space of all possible spin configurations. Measurement outcomes correspond to sampling from the probability distribution given from Born's rule and the wavefunction. The joint probability distribution is in a space of all possible time series. The joint probability distribution can be sampled to give individual time-series samples. (c) Quantum information theory and information theory concepts can be used to understand the underlying probability distributions.

Progress and Achievements

The funding received from the Physics Foundation has enabled us to successfully develop a new method for time-series analysis. Our new method has been incorporated into a new open-source and comprehensively documented Julia package, MPSTime.jl (https://github.com/joshuabmoore/MPSTime.jl), so that our algorithms can be used by analysts working on problems across fields and industries, maximising impact.

We have also released a research paper that explains the theory underlying our new algorithms and comprehensively benchmarks their performance. The preprint of this work has been made available on the *arXiv*: https://arxiv.org/abs/2412.15826.

Our paper focuses on two main applications of our new quantum-inspired formalism imputation and classification, summarized below.

Imputation

Imputation entails filling in missing (or corrupted) values in a time series using knowledge of the values that were measured.

Imputation has broad applications in real-world datasets, such as when measurement artifacts occur, or sensors temporarily go down. Our approach, MPSTime, builds a joint probability distribution of the time-series process and uses it to find the most likely values for the missing data. A summary of our results for ECG data is shown in Figure 2. In our tests, MPSTime exhibited highly competitive performance, often outperforming other state-of-the-art analysis methods.

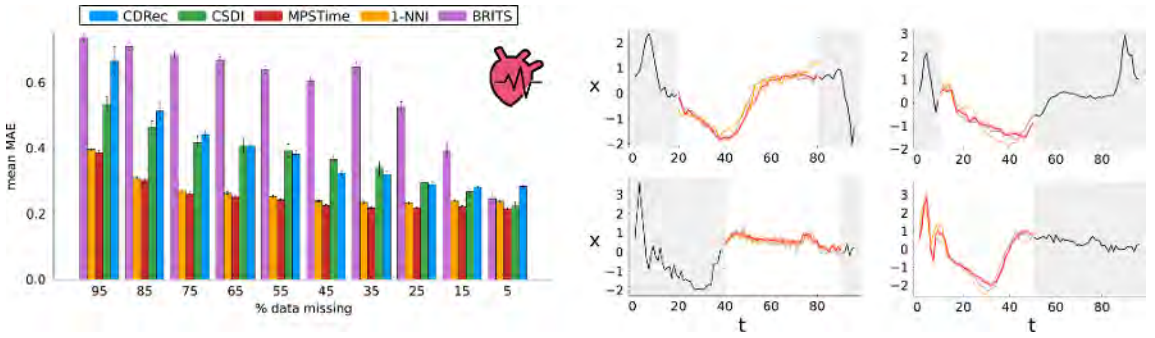


Figure 2. Left: Performance of MPSTime compared with other methods using the ECG200 dataset (lower is better). Right: Sample imputation on test set. Grey windows show known data while white windows show missing values. MPSTime imputation results (red) is compared with first nearest neighbour (yellow), while the actual values are in grey.

Classification

Time-series classification entails infering a class label for a time series given a set of training examples from each class. For example, determining whether an ECG reading indicates a patient has a disease or is healthy is a time-series classification problem. We tested MPSTime on classification problems in medicine, industry and astronomy and compared our results with state-of-the-art classifiers.

The results, shown in Figure 3, demonstrate that MPSTime is again competitive with state-of-the-art time-series classifiers, yet is much more efficient to train and supports a range of important analytics that enhance interpretability.

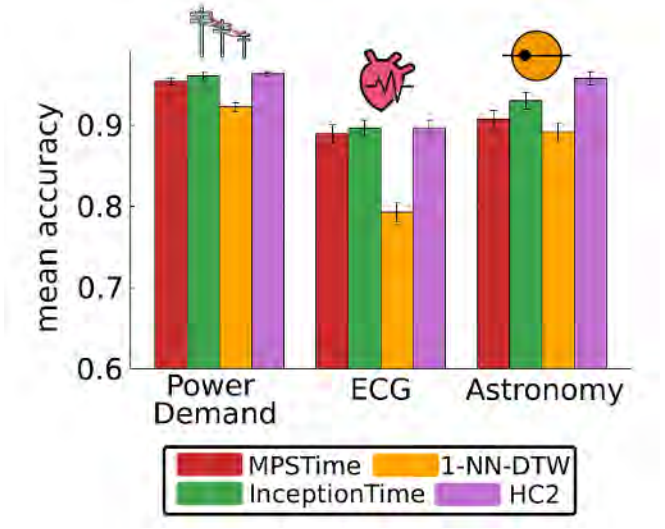


Figure 3. Performance of MPSTime compared with other classifiers on the Italy Power Demand, ECG200 and Kepler datasets. MPSTime exhibits performance that is competitive with that of much more complex and computationally intensive classification approaches.

Student Engagement and Team

We used our project funding to hire two research assistants, Joshua Moore and Hugo Stackhouse. With the supervision of CIs Mahmoodian and Fulcher, over a period of more than one year, these research assistants performed the research in developing and testing our new algorithms, developed the open MPSTime.jlpackage, and prepared our manuscript.

The MPSTime team also jointly supervised an honours student, Angus Rutherford, who graduated in 2024 with first class honours. We have now attracted a new honours student, Lukas Robinson, who will continue the development of MPSTime with a focus on developing an MPS-based forecasting algorithm. And Research Assistant Joshua Moore has just started his PhD, supported by an RTP scholarship, containing a component that will continue developing the MPSTime approach.

In summary, as well as supporting the development of an open code package and a substantial and novel scientific manuscript, the Foundation's support has thus also seeded a productive and enduring new interdisciplinary collaboration between Mahmoodian (quantum theory) and Fulcher (complex physical systems).

Dr Sahand Mahmoodian
and Associate Professor Ben Fulcher
Project Leads

Physics Grand Challenges 2023 Update
Nanostructured Textiles for a Sustainable Warming World

Aim and Background

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 project 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.

Progress and Achievements

The project started in 2024, with a two-pronged approach. The first is to modify natural fibres, such as cotton, and the second is to design structured synthetic fibres from the ground up. Using natural fibres has substantial potential benefits, including sustainability, breathability, wide acceptance of the fabrics by both industry and the public, but is technically very challenging, in particular due to natural variability of the fibres.

It is thus a high-risk high-reward research avenue. In contrast, synthetic fibres allow in principle much greater control over inner and outer structure from the outset, but are only suitable for smaller markets such as for extreme sports or emergency and defence applications.

Significant progress was made in a systematic exploration of surface modification of cotton fibres through chemical and physical treatments. These included attaching mineral nanocrystals (such as zinc oxide, as used in sunscreen, figure 1.), but also intrinsic nanostructuring of cotton fibres without separate scatterers, using mechanical stamping and sulfuric acid treatments. Intrinsic nanostructuring is

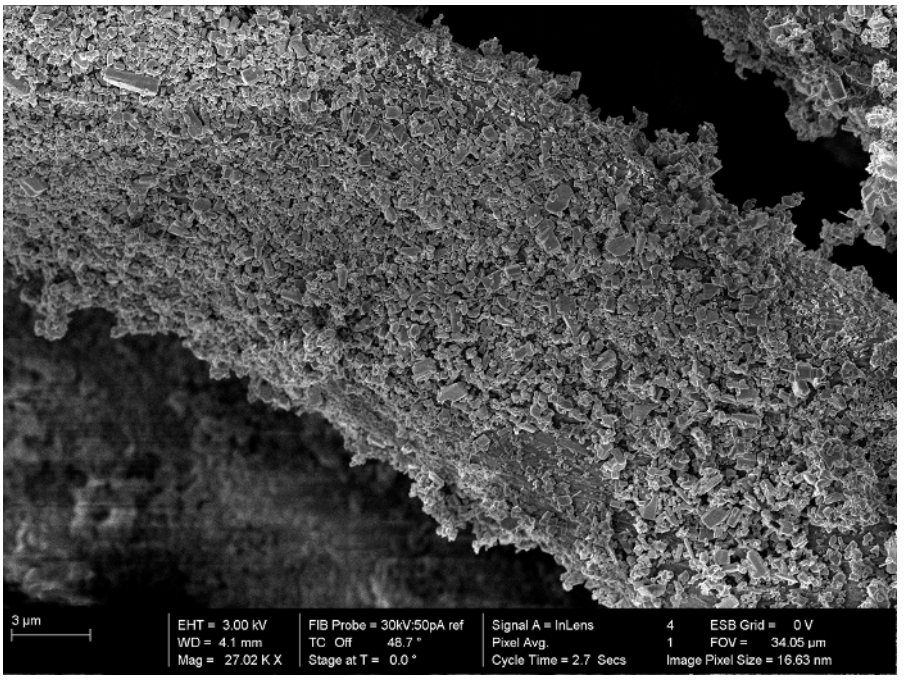


Figure 1.
Cotton fibres with zinc oxide nanocrystals attached.

Figure 2. Drawing microstructured polyurethane fibre.

desirable, as it could be more durable than surface-attached nanocrystals and could more readily preserve desirable properties such as feel, strength and breathability.

On synthetic fibres, exploratory work in drawing microstructured polyurethane fibre showed promising results (figure 2.), but highlighted the inadequacy of our current large-scale drawing tower for small sample preparation as is required for systematic and fast exploration of drawing parameters. Prof Fleming is working on a table-top drawing set-up that will accelerate progress.

Theoretical work on optimizing structures has been delayed due to staffing difficulties. We are currently advertising for a research associate position with a speciality in electromagnetic modelling to optimize fibre structures to direct our fabrication efforts.

Student Engagement and Team

PhD student Ming Gao, directed by Dr Alex Song and Prof Boris Kuhlmey, is the driving force behind the systematic exploration of surface nanostructuring of cotton fibres . He was joined by Engineering masters student Yinxiang Xiong, and physics summer research student Reef Turner for additional work on cotton.

Physics honours student Daniel Glass will be working on developing fast topological optimization methods for radiative cooling in longitudinally invariant fibres, which will feed into the synthetic fibre work. One more PhD student on fabrication is due to start in 2025.

Professor Boris Kuhlmey
Project Lead

Physics Foundation Scholarship
Inaugural Round

The Physics Foundation Scholarship is a high impact initiative aimed at attracting top talent from around the world to the School of Physics and pushing the boundaries of research within the School .

The Physics Foundation Scholarship was devised by Head of School Professor Tara Murphy to attract the best students from Australia and around the world to undertake a PhD at the School of Physics. The scheme is funded by the Physics Foundation.

By providing a full stipend and additional funding for conferences and other career building activities, the scheme aims to raise the profile of the students and promote the research at the School more broadly.

The generous scholarship will improve the student experience. Students are relieved of financial pressure allowing them to focus on their research and career regardless of their financial background.

The Scholarship recipients are not only exceptional academically, they are on a path to be future leaders, motivated to make a positive change in science and the broader community. The Scheme will offer additional training to help the students reach their goals.

The first cohort of student scholarships were awarded in 2024. to the following recipients:

- Alejandro Aguilar Nieto - Supervisor Professor Archil Kobakhidze
- Robin Joshi - Supervisor Professor Scott Croom
- Vasudev Mittal - Supervisor Professor Geraint Lewis
- Libertad Rojas Yanez – Supervisor Professor Stefano Palomba

Image: The inaugural Physics Foundation Scholarship recipients.

Physics Foundation Scholarship
Meet the Scholars

Alejandro Aguilar Nieto

My name is Alejandro Aguilar Nieto, and I am an international student from Mexico City. I've always been amazed by the beauty and complexity of the universe we live in. I was privileged enough to study my bachelor's degree in physics at the Faculty of Sciences at UNAM, the top university in Mexico. During my degree I developed a particular interest in cosmology and black hole physics. My undergraduate thesis focused on no-hair theorems for black holes in modified gravity theories.

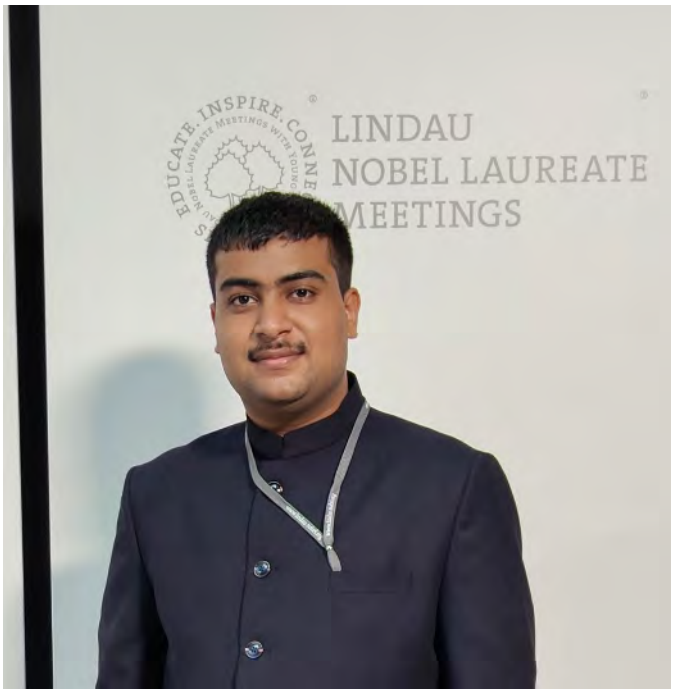
After finishing my bachelor's degree, I pursued a master's degree in astrophysics at ICN, UNAM. My master's research project focused on self-interacting scalar fields surrounding a Schwarzschild black hole, which resulted in its publication on a highly ranked, peer-reviewed journal.

Thanks to the Physics Foundation Scholarship, I was able to take my next step in academia, allowing me to start my PhD at The University of Sydney. Under the supervision of Dr Archil Kobakhidze, I will be exploring the fundamental physics of axions and gravitational waves by studying them on a spinning black hole background. I am deeply enthusiastic about doing research, driven by the idea of expanding the boundaries of human knowledge and contribute to the advancement of science.

Robin Joshi

My journey in research began at Queen's University in Canada under the supervision of Professor Lawrence Widrow. There I used isolated, Milky Way-like galaxy simulations to study how the dark matter halo influences the formation and evolution of structures like bars and warps in the stellar disk. The Physics Foundation Scholarship gives me the opportunity to continue my journey in research and further explore the field of galaxy astrophysics. Here at the University of Sydney, under the supervision of Scott Croom, the plan is to use data provided by galaxy surveys like Hector to gain insight into the evolution of galaxies. My goal is, with the training and expertise I develop at the University of Sydney thanks to the Physics Foundation Scholarship, to be a part of the effort in the astrophysics community to better understand the physics of observed phenomena in the Universe.

Physics Foundation Scholarship
Meet the Scholars



Vasudev Mittal

I am an Indian aspiring cosmologist who enjoys working to reconcile the conflicts between observation and theory. Using both my enthusiasm and scientific knowledge, I am also attempting to contribute to the betterment of society. Thanks to the scholarship, I've developed my abilities as a developing scientist and potential scientific leader.

In contrast to other doctoral grants offered to graduate students, it gave me the freedom to undertake research without academic pressure or bias. I've benefited from learning about scientific outreach from some of the best researchers and how to motivate the next generation of scientific leaders. I plan to engage in the foundation's outreach programs and teach science to people of all ages and backgrounds in addition to carrying out innovative scientific research.

Libertad Rojas Yanez

Inspired by the opportunity to understand the once inexplicable phenomenon of our universe, I traveled across the world to pursue a career in Physics. Starting in Bolivia, my home country, all the way to Canada, where I completed my undergraduate studies. During these years, I had the opportunity to learn from a diverse group of people at conferences, training camps, and internships, exposing me to the multiple realms of physics. However, nothing intrigued me more than the field of light manipulation. I was left astonished by how the research done in Optics, particularly in Photonics, has the potential to improve various aspects of our community significantly. This led me to realize that along with my goal of contributing to deepening our understanding of the fundamental laws governing our universe, I also wanted to be able to advance or create instrumentation that has the potential to offer practical benefits to society. Receiving the Physics Foundation Scholarship is an honor that has given me the invaluable opportunity to continue my studies as a PhD student and dedicate myself to contributing to the scientific community.

"We need to treasure our STEM leaders like football stars – make them feel special – because they are"

Professor Harry Messel AC CBE

International Science School

From Quanta to Quasars - ISS2025 is coming!

"Thank you for giving me this opportunity to attend ISS, and live the best two weeks of my life!" Student at ISS2023

ISS2025, the 44th Professor Harry Messel International Science School, will run from Monday 7 July to Friday 18 July 2025. With a theme of From Quanta to Quasars, the ISS will explore a wide range of cutting-edge research, from quantum engineering to cosmology, from sustainable energy to protein folding.

Incredibly, this life-changing event is entirely free for all participants, with full scholarships provided by the Physics Foundation at the University of Sydney. The ISS aims to seek out promising young STEM scholars wherever they are, and we want to ensure no talented student misses out due to financial constraints.

The ISS gathers over one hundred talented year 11–12 students from across Australia and around the world for two weeks of lectures and activities, as well as a rich social program. Students attend from China, India, Japan, New Zealand, Singapore, Thailand, the UK and the USA, as well as every state and territory of Australia, and are selected for their academic achievements in science as well as their enthusiasm, leadership and potential.

Since 2005, five scholarships have been reserved at each ISS for talented Indigenous Australian students — in 2025 we will again seek out and celebrate our best Indigenous students from across the country.

Electrifying Lectures

The backbone of the program is the ISS lecture series, and this year we have another fantastic line-up of speakers across a wide spectrum of research fields— from quantum computing to the fate of the cosmos — including:

- **Nobel Laureate Prof. Donna Strickland** from the University of Waterloo, Canada, winner of the Nobel Prize for Physics in 2018 for her work on pulsed lasers.
- **Prof. Katie Mack**, the Hawking Chair in Cosmology and Science Communication at the Perimeter Institute, Canada, on the fate of the universe.
- **Associate Prof. Sven Teske**, Research Director, Institute for Sustainable Futures, University of Technology Sydney, on energy engineering, climate change, and hope
- and the irrepressible **Dr Karl Kruszelnicki**, radio and TV science guru, Sleek Geek and the University of Sydney's Julius Sumner Miller Fellow, with rollercoaster-ride through his Great Moments in Science

You can enjoy lectures from the last twenty years of ISS events at: youtube.com/TheSydneyISS

Top Image: Getting experimental in the chemistry labs. Bottom Image: ISS Scholars get to experience whole new worlds in STEM research.

Awe-inspiring Activities

Around the scientific talks, the students take part in hands-on activities and laboratory tours, led by staff and students from across the Science and Engineering Faculties at the University of Sydney.

Students will get hands-on with solar cell production, get a back-stage tour of the university's museum collections, compete for glory in the Science & Engineering Challenge, and grill postgraduate students about their research and experience of university life.

Spectacular Socials

Outside the formal academic program, the ISS scholars also enjoy a rich social life, giving them opportunities to make new friends from all over the world. They see the sights of Sydney from an evening harbour cruise, meet alumni and supporters of the ISS at the Gala Reception in the University's Great Hall, and show off their musical, dance and comedy skills at the infamous ISS Talent Night.

Inspire the Next Generation of STEM Leaders

The Physics Foundation provides the entire ISS program free for all participating students — including accommodation and meals, transport to Sydney, and all program events and activities.

We could not do this without the generous support of hundreds of donors, big and small, from private individuals to state and federal governments, over the last 60 years.

But we're not finished. **The Foundation seeks to raise $10 million, to be maintained as a capital investment, to ensure that the ISS continues in perpetuity**.

You can help us achieve this goal with a donation to the Messel Endowment — and join us in lighting the fires of inspiration for the next generation of leaders in science and mathematics, health and medicine, engineering and technology.

To support the International Science School visit **give.sydney.edu.au/physics-foundation** and direct your gift to the **Messel Endowment**

"This was the best thing that I have ever done and I am so grateful for the opportunity! Thanks for an amazing two weeks, I will never forget them." Student at ISS2023

Image: ISS2023 scholar thanks speaker Prof. Alan Duffy

Dr Karl Kruszelnicki AM
Julius Sumner Miller Fellow Report

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 public across a multitude of platforms.

Dr Karl in his capacity as Julius Sumner Miller Fellow is currently supported by the Faculty of Science, working with the Partner Engagement and Outreach team.

University of Sydney Events

Karl presented two one-hour talks for the Leadership in STEMM subject for the University's high-achievers Dalyell stream; a 'Great Moments in Science' show for the Sydney Science Forum at the Seymour Centre; a talk for students at the Honi Soit Conference; a **Physics Society talk**: and a presentation for the Music, Environment and Climate Change students.

Karl attended the 100 Years Celebration Dinner for the Physics Building and contributed a piece about his (thirty-year) position as the Julius Sumner Miller Fellow to the anniversary publication. He was recognised as a previous recipient of the Order of Australia Award at the Honours Reception at Sydney Town Hall and presented a science show for the University's Alumni Festival.

In collaboration with the Australian Museum, Karl promoted and presented the University of Sydney Sleek Geeks Science Eureka Prize for primary and high school students.The finalists in all categories enjoyed a lunch and a Q&A with Karl before enjoying the winner presentations at the Australian Museum.

National Science Week

Karl was enlisted as an ambassador and promoted National Science Week across radio and television. He kicked off his Science 'fortnight' at the Beaker Street Festival in Tasmania with a schools' show for 1000 students, and a 'Dr Karl Vs Audience' evening game show at Hobart City Hall. Science communicators got some tips from Karl's SciCom workshop before he performed his solo show to the public. Karl was a 'roving scientist' answering questions in a pub and attended the MONA lunch forecasting food production in 2050 in the light of climate change.

Sydney Science Week began with an online Q&A for the NSW Department of Education to over 14,000 students across Australia. Following the success of this session, Karl has been invited to deliver a series of these online Q&As in 2025.

Image: Science Week in the Blue Mountains

The University of Sydney's flagship event for Dr Karl was held in the Blue Mountains Theatre in Springwood. Local schools were overwhelmed with the opportunity to hear from Karl about careers in science, and the evening public show sold out.

Karl also celebrated Science Week appearing on ABC's Play School making slime snot and educating the kids on snot facts!

Karl finished his science fortnight with a 'Seriously Strange Science' talk and Q&A at the Australian Museum for families and children.

Schools

Online school Q&As continued twice weekly. Karl spoke to over 4,000 students from 50 schools across Australia.These included: the Qld Virtual STEM Academy that supports rural and remote state schools; primary school students from the Young Environmental Leaders in South Australia; Katherine School of the Air residential day; Mensa global citizens under sixteen; and a school in Malaysia.

Karl receives many invitations to visit schools. This year he presented 'Future Careers in Science' presentations to International Grammar School, Abbotsleigh High, Aurora College (a virtual selective high school residential day for students from rural and regional areas), Kambala High and Indooroopilly High.

He presented two shows in Bundaberg for the students at Gin Gin High School and Gin Gin Primary School, as well as a public show in the Community Hall. (These Gin Gin events are part of a unique program to teach the concept of "atoms" to primary school students – beginning in Kindergarten!).

Karl supported the University of Sydney's Easter Show 'Grow with Us' prize with personally signed books and online Q&As for the two winning schools.
Year 12 physics students from Bega High joined Karl in his university office for his online Q&As with schools; year 12 students seeking guidance for careers in science benefitted from zoom sessions with Karl, as did primary school students interviewing Karl for their school project.

Karl collaborated with Westwords (an organisation to encourage students in Greater Western Sydney to read and write) with a 'Curiosity and Creativity' online Q&A for six of their schools. He also appeared on the Captain Starlight Channel (closed-circuit hospital TV channel found in every pediatric hospital in Australia) to take questions from kids in hospital.

Television

Karl featured in an episode of ABC's Eat the Invaders, a series exploring the possible solution of eating invasive plants and animals to restore the land's biodiversity.

His hugely successful six-part documentary series Dr Karl's How Things Work debuted on ABC TV and featured Karl inside factories across Australia explaining the intricate workings of our most productive manufacturing plants.

Top Image: Aurora College Residential Day.
Bottom Image: Dr Karl asking all the important questions.

Karl explained the science of fireworks for ABC's TV coverage of New Year's Eve and appeared regularly throughout the year on Channel Ten's The Project, explaining the latest science stories.

Radio

Karl's weekly five hours of national ABC science radio segments and CHAI FM in South Africa continued throughout 2024, adding in ABC Canberra and ABC Brisbane, plus commercial stations Triple M and 2GB. Karl's Science Week guests included Australian astronaut Katherine Bennell-Pegg.

Social Media

Karl collaborated with the Australian Open to make TikToks about tennis. TikTok followers are now at 520K and growing. Karl was the winner of the 'High-Quality Content Creator of the Year' at the TikTok Awards.

Karl's social media followers continue to grow with Facebook numbers now 191K. Instagram followers are up to u7ub 135K, and X now sits at 328K.

Karl's website, drkarl.com is the go-to hub of all things Karl. Karl's weekly ABC 'Science explainers' videos continued to entertain and inform the public across the social platforms. Views reach up to 240K per video.

Overseas Activities

Karl was a panelist for the online SkeptiCal conference (Northern California) on 'Media Literacy and the TikTok Generation'.

In October Karl gave talks at The Royal Institution and New Scientist in London. He was a guest of the Royal Society for the 2024 Science Book Prize Award Ceremony.

Karl was a guest speaker at the 2024 World Conference on Science Literacy (WCSL) held in Beijing. He gave a presentation on how to promote science literacy through curiosity.

Podcasts

Dr Karl has a weekly ABC triple j podcast and University of Sydney podcast 'Shirtloads of Science' (average download per Shirtloads episode is 20K). In June the triple j 'Science with Dr Karl' podcast reached its highest ever audience on record at 144K for the month. Shirtloads featured University of Sydney academics including Dr Laura Driessen, Professors Geraint Lewis, and Simon Ho. Other guests included Professor Michael Mann in New York, visiting UK mathematician and YouTuber Tom Crawford, and Richard Scolyer (joint 2024 Australian of the Year).

Writing

Dr Karl continued his regular columns in Australian Geographic magazine and University of Sydney's Science Alliance newsletter (4000 members). Karl published his 48th book about his life to date, A Periodic Tale: My Sciencey Memoir. The book was received to great acclaim and Audible awarded it one of the'Best Listens' of 2024. The book continues to inspire people to be curious, follow their passions and to always ask questions!

Top Image: Science wins TikTok!
Bottom Image: Sunshine Coast Book Tour for A Periodic Tale.

Festivals and Conferences

Karl was a guest of the World Science Festival Brisbane and gave a science careers talk to 850 high school students and two public shows to over 2,500. He gave the opening keynote address for Skepticon Sydney.

Other appearances included Blue Mountains Writers' Festival and the Lost Paradise Festival.

Mentoring and Media/Speaker Training

Karl took several University of Sydney academics through his science communication training in preparation for festival appearances.

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, a science communication talk from Dr Karl, and joined him for his online school Q&As.

Awards

Karl was awarded a Bellagio Center residency from The Rockefeller Foundation to develop a strategy using AI to counter climate change disinformation. He will take up this four-week residency in Italy in 2025.

Karl was awarded the NSW Senior Australian of the Year in recognition for his services to the community as a science enthusiast and educator. In December Karl received an Honorary Doctorate from the University of Newcastle for his dedication to the sciences.

Image: 2025 Senior Australian of the Year for NSW.

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 2024 consisted of the following members. They were all eligible to attend three meetings in 2024 including 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: 2
- Mr Paul Chadwick
  Meetings attended: 2
- Emeritus Professor Lawrence Cram AM
  Meetings attended: 3
- Professor Gemma Figtree AM FRACP FCSANZ FAHA
  Meetings attended: 3
- Mr James Read
  Meetings attended: 3

Council members were elected at the Foundation's AGM on the 28th of March 2024. 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 2024: 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

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 its 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 2024 of the University of Sydney Physics Foundation fully comply 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: 27/02/2025

The University of Sydney

Uni of Syd Physics Foundation (L7500_SCI_FND_PHYS)

Income Statement

for the Period Ended 31 December 2024

	Note	31 December CY2024	31 December CY2023
INCOME			
Grants		0	0
Scholarships, Donations and Bequests		13,225	17,470
Business and Investment Income		62,283	70,800
Realised Gain / (Loss) on Investments		4,591,489	2,413,181
Investment Administration Fee		(128,207)	(121,554)
Internal and Other Income		0	1,698
Total Income		**4,538,790**	**2,381,595**
EXPENDITURE			
Salaries	4	1,063,799	916,163
Consumables		0	4,758
Equipment and Repairs/Maintenance		234	2,653
Physics Grand Challenges Seed Funding	5	350,000	1,067,950
Services and Utilities		19,269	142,529
Travel, Conferences, Entertainment		656	321,479
Consultants and Contractors		41,100	5,486
Student Costs and Scholarships		67,410	32,808
Other expenses		10,075	74,613
Total Expenditure		**1,552,543**	**2,568,439**
Surplus / (Deficit)		**2,986,247**	**(186,844)**
Accumulated Funds		34,567,188	34,380,799
Accumulated Funds Adjustments		0	373,233
Total Accumulated Funds		**37,553,435**	**34,567,188**

Notes to Financial Statements (….continued)

4. The 2024 salary expenditure of $1,064k includes $172k of ISS-related salary expenses and $890k of education related funding support for the salaries of six School of Physics staff members.

5. Final Grand Challenge Seed funding.

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

Carma du Plooy

4/03/2025

Carma Du Plooy
Finance Director
Financial Services - Science, E

Thomas Sapina

Thomas Sapina
Associate Director Finance
Faculty of Science

The University of Sydney

Uni of Syd Physics Foundation (L7500_SCI_FND_PHYS)

Balance Sheet

as at 31 December Calendar Year 2024

	Note	31 December CY2024	31 December CY2023
ASSETS			
CURRENT ASSETS			
Short Term Funds	3	1,266,213	(592,429)
Total Current Assets		**1,266,213**	**(592,429)**
NON CURRENT ASSETS			
Medium/Long Term Investments	3	36,287,222	35,159,618
Total Non Current Assets		**36,287,222**	**35,159,618**
TOTAL ASSETS		**37,553,435**	**34,567,188**
LIABILITIES			
CURRENT LIABILITIES			
NON CURRENT LIABILITIES			
NET ASSETS		**37,553,435**	**34,567,188**
EQUITY			
Accumulated Funds		37,553,435	34,567,188
TOTAL EQUITY		**37,553,435**	**34,567,188**

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 $7,392,031 of the Messel Endowment ($7,696,706 in 2023) 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

Physics Foundation (L7500_SCI_FND_PHYS)

Statement of Changes in Equity

for the Year Ended 31 December 2024

		Foundation Operations (L7501)	Messel Endowment (L7505)	International Science School (L7502)	Total
		$	$	$	$
Balance as at 1 January 2022 [Partial-ISS Year]		**27,815,145**	**7,096,220**	**54,952**	**34,966,317**
Add (Less):	Accumulated Funds Adjustments	315,261	0	0	315,261
Add:	External Income (excluding Gain/Loss on Investments)	19,951	14,806	113	34,870
Add (Less):	Gain / (Loss) on Investments	392,815	116,522	0	509,337
Add (Less):	Intra-Foundation Funds Transfer	0	0	0	0
Less:	Funds Transferred to Physics	(9,550)	0	0	(9,550)
Less:	Expenditure	(1,183,393)	0	(252,044)	(1,435,436)
Balance as at 31 December 2022		**27,350,230**	**7,227,548**	**(196,978)**	**34,380,799**
Balance as at 1 January 2023 [Full-ISS Year]		**27,350,230**	**7,227,548**	**(196,978)**	**34,380,799**
Add (Less):	Accumulated Funds Adjustments	373,233	0	0	373,233
Add:	External Income (excluding Gain/Loss on Investments)	40,549	46,351	3,069	89,968
Add (Less):	Gain / (Loss) on Investments	1,868,819	422,807	0	2,291,626
Add (Less):	Intra-Foundation Funds Transfer	0	0	0	0
Less:	Funds Transferred to Physics	(1,067,950)	0	0	(1,067,950)
Less:	Expenditure	(725,474)	0	(775,015)	(1,500,489)
Balance as at 31 December 2023		**27,839,406**	**7,696,706**	**(968,924)**	**34,567,188**
Balance as at 1 January 2024		**27,839,406**	**7,696,706**	**(968,924)**	**34,567,188**
Add (Less):	Accumulated Funds Adjustments	0	0	0	0
Add:	External Income (excluding Gain/Loss on Investments)	16,261	58,785	461	75,508
Add (Less):	Gain / (Loss) on Investments	3,593,868	869,414	0	4,463,282
Add (Less):	Intra-Foundation Funds Transfer	0	(1,232,875)	1,232,875	0
Less:	Funds Transferred to Physics	(350,000)	0	0	(350,000)
Less:	Expenditure	(1,014,598)	0	(187,945)	(1,202,543)
Balance as at 31 December 2024		**30,084,937**	**7,392,031**	**76,467**	**37,553,435**

For more information
The University of Sydney
Physics Foundation
physics.foundation@sydney.edu.au
www.sydney.edu.au/science/schools/school-of-physics/physics-foundation.html