Australian Institute of Physics NSW Branch

2023 Postgraduate Awards Event Schedule

The 2023 Awards Event is sponsored by:

THE ROYAL SOCIETY OF NEW SOUTH WALES
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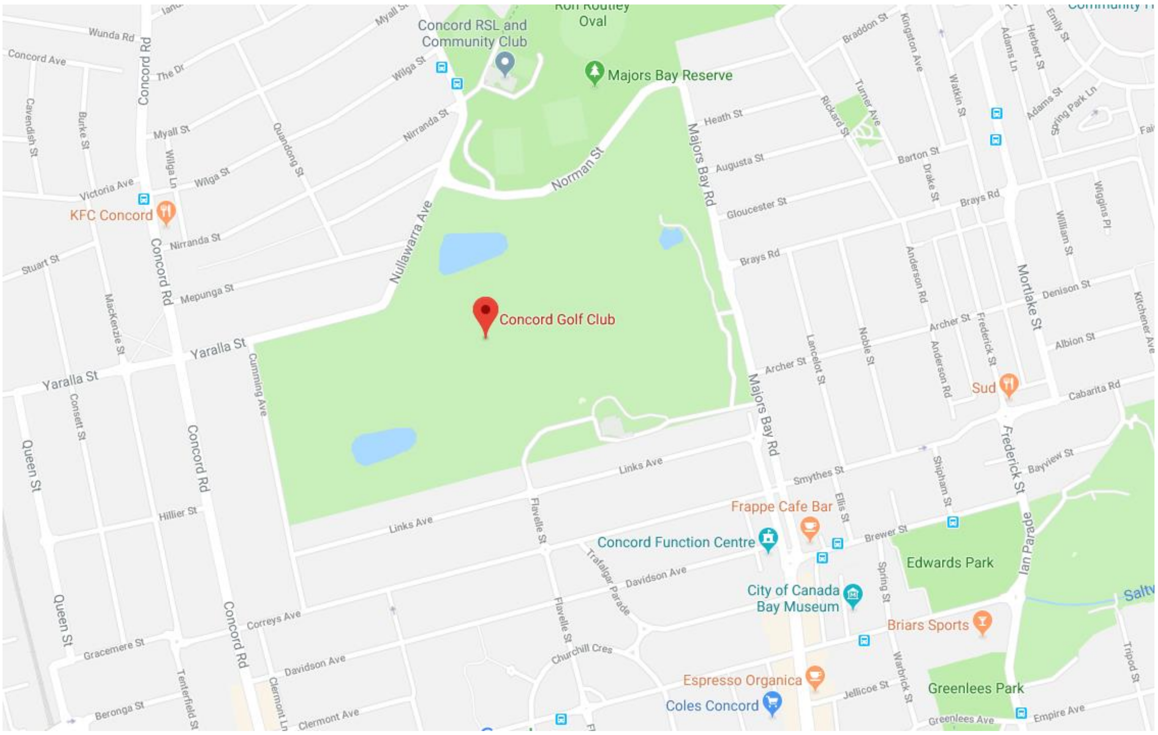
2023 AIP Postgraduate Awards

The **NSW AIP Branch** will hold its **Annual Postgraduate Awards event** on **Tuesday 14 November 2023 at the Concord Golf Club, 190 Majors Bay Road Concord (Entry via Flavelle Street).**



Each University has invited a postgraduate physics nominee to compete for the **AIPNSW Postgraduate medal** and the **RSNSW Jak Kelly prize.**

These awards have been created to encourage excellence in physics postgraduate work, and all nominees who participate in the Postgraduate Awards Day will receive a **special award** recognising the nominee's high standing.

Students will make a **20-minute presentation** on their postgraduate **research in Physics**, and the presentation will be judged on the **criteria (1) content and scientific quality, (2) clarity and (3) presentation skills as included in the judges' criteria.**

Event Schedule

- Presentations at the **Concord Golf Club, 190 Majors Bay Road Concord (Entry via Flavelle Street)** – **10.00am**
- Presentation of *Awards and Prizes* – **1.15pm**
- *Lunch and Refreshments* – **1.30pm**
- See further details in the Schedule on page 5

2023 Judging Panel

- Dr Jesse Shore – **Prismatic Sciences**
- Tibor Molnar – **Honorary Research Associate, Department of Philosophy, University of Sydney**
- Dr Shaila Akhter – **Australian Institute of Physics NSW**
- Dr Erik Aslaksen **– The Royal Society of New South Wales**

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Criteria for AIP Postgraduate Awards

All candiates will present a **max 20-minute presentation** *(not including questions)*. The judges score and rank the candidates according to: (1) Content and Scientific Quality, (2) Clarity and (3) Presentation Skills. The judges combine their results to determine the winner. *Decisions by the panel are final*.

1. **Content and scientific quality are important criteria**. The presentation must be interesting, and the material should be seen to be significant within the field of research. Context is important for establishing what the state of current research in the field is and how the described research contributes to and extends current knowledge. The candidate must balance the competing demands of providing a clear explanation to the non-specialist and illustrating the techniques and methods to allow a meaningful assessment of the presenter's own understanding and contributions to the research. The context can be further clarified during the question-and-answer session.

1 = Strongly Disagree
3 = Neither Disagree nor Agree
5 = Strongly Agree

A. Content and Scientific Quality Matrix				**Total____/20**	
(i) Interesting	1	2	3	4	5
(ii) Significant	1	2	3	4	5
(iii) Addresses Research Gap/Need	1	2	3	4	5
(iv) Contributes and Extends Knowledge	1	2	3	4	5

2. **Clarity** is a skill which is required to communicate a subject requiring years of study into a 15-minute presentation. The judges are looking for the presenter's ability to communicate the essence of the research without becoming excessively encumbered with detail. A proper introduction, good exposition and meaningful conclusions are important factors in providing a clear presentation.

B. Clarity Matrix				**Total____/20**	
(v) Communicates Essence	1	2	3	4	5
(vi) Good Introduction	1	2	3	4	5
(vii) Good Exposition and Explanations	1	2	3	4	5
(viii) Meaningful Conclusion	1	2	3	4	5

3. **Presentation skills** include the best use of audio-visual aids, speaking ability, eye contact, efficient use of time, projecting a professional and confident attitude, preparedness and response to questions.

C. Presentation Skills Matrix				**Total____/20**	
(ix) Preparation and Use of Time	1	2	3	4	5
(x) Use of Audio-Visual	1	2	3	4	5
(xi) Professional and Confident	1	2	3	4	5
(xii) Response to Questions	1	2	3	4	5

2023 AIP Postgraduate Schedule

- ***10.00am*** **Welcome by Dr Frederick Osman (AIP Awards Coordinator)**

- ***10.05am*** **Jamie Andres ALVARADO-MONTES, Macquarie University, School of Mathematical and Physical Sciences**

  Tidal Evolution and Detectability of Close-In Extrasolar Systems

- ***10.30am*** **Ruomin ZHU, University of Sydney, School of Physics**

  Toward more efficient and sustainable AI with physical neural networks

- ***10.55am*** **Andrew MANSOUR, University of New South Wales, School of Physics**

  Manifestation of Physics Beyond the Standard Model in Atomic and Molecular Phenomena

- ***11.20am*** **Ivan TOFTUL Australian National University, Research School of Physics**

  Resonance-Driven Optical Torques at the Nanoscale

- ***11.45am*** **Jake HORDER, University of Technology Sydney, School of Mathematical and Physical Sciences**

  Quantum Light in Flatland: sourcing indigo photons from nanostructures in hexagonal boron nitride

- ***12.10pm*** **Jacob JOHNSTONE, University of Newcastle, School of Information and Physical Sciences**

  Aluminium ion batteries – A solution to the merging trillion-dollar energy storage market

- ***12.35pm*** **Jackson ALLEN, University of Wollongong, School of Physics**

  How Neutrons Have Been Discovering New Magnetic States of Matter for Future Information Technologies

- ***1.15pm*** **Presentation of NSW Community Outreach to Physics Award and AIP NSW Postgraduate Awards**

- ***1.30pm*** **Lunch and Refreshments**

Tidal Evolution and Detectability of Close-In Extrasolar Systems

Jaime Andres ALVARADO-MONTES
School of Mathematical and Physical Sciences, Macquarie University

Abstract

Any pair of extended bodies in close proximity will strongly interact and exchange angular momentum with each other and deform their shape due to gradients in their gravitational field. Therefore, close-in planetary systems composed of giant bodies can help us test tidal models and work as a probe to constrain the interior structure of stars and planets. Considering the discovery of thousands of giant exoplanets with orbits of a few days (or less than a day in some cases) over the last four decades, in this talk I will show how tidal interactions affect the evolution of planetary systems. This study includes effects such as photo-evaporation of atmospheres, stellar wind, stellar spin-up, and material loss from stars, planets, and moons. I analyze the tidal evolution of these bodies by exploring the dissipation of heat in their interiors and, in the most extreme cases, I have found that tidal interactions will make close-in giant planets and moons undergo orbital migration that could inevitably lead to their destruction. In spite of the systematic prediction of orbital migration by tidal models, observational evidence to confirm it is still scarce. I will also demonstrate that some systems' orbital migration rate is so rapid that measurements of their migration (by detecting changes in their observational features) could be made within the next few years. I conclude by showing how in spite of the plethora of exoplanets discovered to date, none of them have the same characteristics as those of our unique Solar System. This means that there are many different features that exist in our Solar System yet to be found around other stars. As such, my research is a step forward towards a better understanding of how those features can eventually be detected and studied by improving the current models of planetary tidal evolution.

Toward more efficient and sustainable AI with physical neural networks

Ruomin ZHU
School of Physics, University of Sydney

Abstract

As Moore's law approaches its limits and AI software demands continue to grow exponentially, the necessity for a new computing paradigm becomes increasingly evident. Neuromorphic engineering has made significant advances in this direction by designing systems that mimic the brain's efficiency, adaptability, and learning mechanisms. One promising approach in neuromorphic engineering aims to harness intrinsic brain-like properties of certain nanomaterials that self-organise into a neural network-like physical structure, with synapse-like electrical nanoscale junctions. Nanowire Networks (NWNs) stand out as a particularly promising avenue in this quest. Their inherent complex brain-like topology mimics the intricate connectomes found within biological neural systems. This structural complexity is further enriched by synapse-like resistive memory (memristive) switch junctions. In this talk, I will present results showing how these neuromorphic properties of NWNs can be harnessed for dynamic information processing. Overall, the results point to the structural complexity of NWNs and the associated rich repertoire of non-linear dynamics as key to enabling "neuromorphic intelligence". This steers us towards a new direction for AI that is more energy-efficient and sustainable than today's technologies.

Manifestation of Physics Beyond the Standard Model in Atomic and Molecular Phenomena

Andrew MANSOUR
School of Physics, University of New South Wales

Abstract

The Standard Model of elementary particles comprises the fundamental building blocks of observable matter. To date, it is one of the most successful theories in physics. Despite this, it is not complete. There remains a list of fundamental physical phenomena which go unexplained by the Standard Model. The first of which is the fact that General Relativity, the most successful theory of gravity to-date, is seemingly incompatible with the Standard Model on the quantum level. The Standard Model is also unable to explain the observed matter-antimatter asymmetry in the universe, fails to supply an adequate candidate dark matter particle and is unable to explain the origin of dark energy. As such, the aim of our research is to formulate and assess various extensions to the Standard Model, and devise mechanisms in which these theories may be tested.

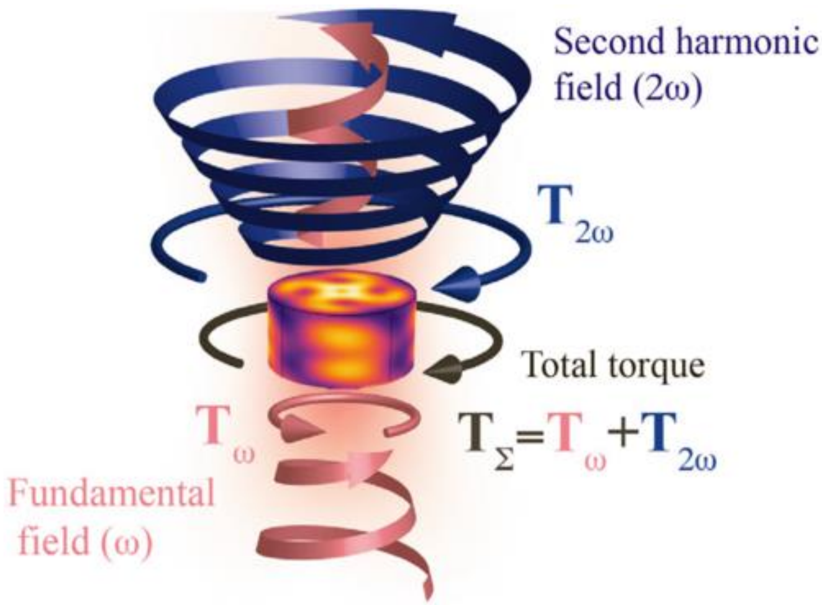
One of the most interesting findings in modern physics is the indication that the values of fundamental constants may be subject to small temporal and spatial variations. This is in direct violation of the laws of physics as we know them, and its study may provide us with a new way of probing possible extensions to the Standard Model. In this talk, I will discuss our research into the temporal variation of fundamental constants and explain how we may search for these variations using atomic spectroscopy measurements. The variations of fundamental constants may be due to an interaction with dark matter, meaning such measurements may also be used to search for interactions of dark matter with standard model particles. I will explore some of the ways in which these interactions may be probed experimentally.

Resonance-Driven Optical Torques at the Nanoscale

Ivan TOFTUL
Research School of Physics, Australian National University

Abstract

Light can carry linear and angular momentum. During scattering and/or absorption the momentum can be transferred from light to a matter on different scales: it can move spacecrafts or manipulate living cells without killing them. What is more intriguing is that light can twist nanoscale objects, which is extremely hard to do with any other tool. The central question of my work is “How to enhance optical spinning torque on nanoparticles”. I will overview the recent achievements in the field, including the physics driving the optically induced rotation. Finally, I will discuss my results to enhance the optical spinning torque using the photonic Mie resonances.



Related works:

- https://doi.org/10.1103/PhysRevLett.130.243802
- https://doi.org/10.1063/5.0091280

Quantum Light in Flatland: sourcing indigo photons from nanostructures in hexagonal boron nitride

Jake HORDER
School of Mathematical and Physical Sciences, University of Technology Sydney

Abstract

At the cusp of a new era of technological capability, controlled quantum systems can now provide unique resources such as superposition and entanglement. Central to these novel technologies is the quantum bit, an exotic mixture of the familiar binary states possible with classical bits. Computing with "qubits" has the potential to accelerate solutions to some special problems in cryptography and optimization, prompting massive investment from commercial enterprises in recent years.

Atoms had been a popular building ground for producing qubits, although isolating individual atoms is difficult. Fortunately, light itself also has an atom-like composition – the photon. Quantum information can be stored in photons in many ways, like polarisation, meaning photons can be used not only to link separate atomic quantum computers together, but are also a substrate for the quantum computation itself.

Hence, there is demand from photonic quantum computation and communication firms for quantum light sources. To be viable, these sources are expected to produce single, identical photons at high rates. A promising platform for sourcing photons is electron traps in two-dimensional materials. A two-dimensional material is crystal structure made of many weakly-connected planar atomic lattices, much like stacks of pre-sliced cheese. Removing single atoms from points in the lattice produces traps for electrons, whose discrete energy levels can be used to make single photons.

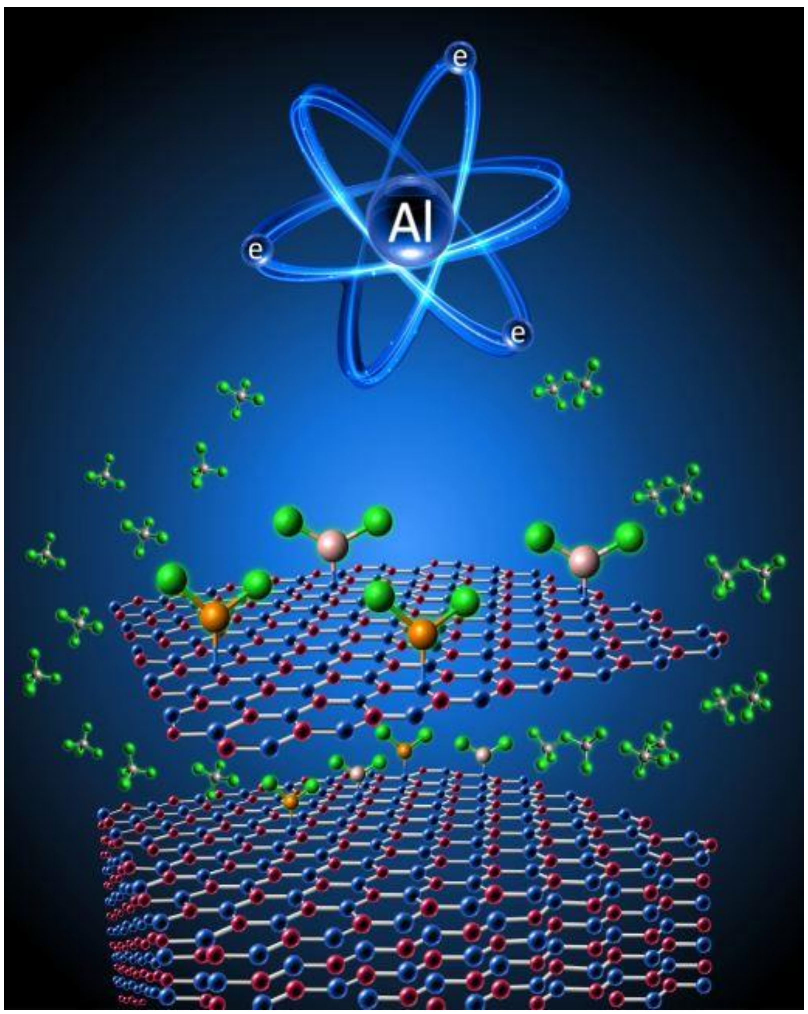
Once the electron-trap single photon sources are created, the physical structure of the two-dimensional material surrounding the trap can be engineered in order to modulate the photon properties and characteristics. Most significantly, the material can be shaped such that the electron trap is effectively embedded in a hall of mirrors, resulting in a strong light-matter interaction ideal for fast production of identical photons. This is an exciting platform for prototyping quantum technologies, and is set for a bright future in the emerging quantum industry.

Aluminium ion batteries – A solution to the emerging trillion-dollar energy storage market

Jacob JOHNSTON
School of Information and Physical Science, University of Newcastle

Abstract

The needs for energy storage are soaring with the sharp rise in renewable energy. In the coming decade lithium and related Li-ion battery materials will come under increasing supply constrain as production struggles to keep up with the sharp rise in demand. Herein I present cutting edge advances in Earth abundant aluminium-ion batteries across all cell components. New, cheaper electrolyte materials coupled with high capacity abundant cathodes that can outperform the standard graphite has brought the tantalising possibility of aluminium-ion battery commercialisation closer.



How Neutrons Have Been Discovering New Magnetic States of Matter for Future Information Technologies

Jackson ALLEN
School of Physics, University of Wollongong

Abstract

The world is experiencing an energy crisis on a perpetually increasing scale as energy use increases year on year. One of the most significant contributions to the increasing energy demand is the information and communication sector, where both device usage and massive server backends consume large fractions of global electricity demand.

One solution to the energy efficiency problem in modern electronics is to explore a new class of technology called spintronics. In simple terms, spintronics allows information to be transmitted by instantly flipping spins – tiny magnets within a material. This enables the creation of new devices that are significantly more efficient not only in terms of energy consumption but also in terms of speed and computational power. Research in this field has the potential to accelerate information technology, and to use less power while doing so.

In order to reach the goals promised by the principles of spintronics, magnetic materials must be understood in much greater detail. In the field of magnetic physics, quantum magnetic systems have gained a lot of recent interest for their capacity to exhibit new magnetic states with untested, yet promising magnetic spin properties. In fact, half of the 2021 Nobel Prize in Physics was awarded for research in the area of spin glasses, one of these recently discovered magnetic states.

The research is now focused on benchmarking the spin properties of promising magnetic materials. The most common technique for this is probing materials with neutrons since neutrons themselves have magnetic spin. Neutron spectroscopy, performed at ANSTO using Australia's nuclear reactor, on magnetic atacamite, a material with promising magnetic characteristics, will be presented. Combining these experiments with theoretical modeling constitutes a case study that deepens our understanding of the spectrum of possible magnetic states in our universe.