Australian Institute of Physics NSW Branch

2018
Postgraduate
Awards
Event

The 2018 Awards Event is sponsored by:

2018 Postgraduate Awards

The NSW AIP Branch will hold its Annual Postgraduate Awards Day on **Tuesday 13 November 2018 at the University of New South Wales, School of Physics, Room G59/60, Level G Old Main Building Kensington Campus.** Each New South Wales University is invited to nominate one student to compete for the **$500 prize** and **Postgraduate medal** on that day.

The Royal Society of NSW will also award the Jak Kelly Scholarship prize of $500 as a separate award category for this event. Students nominated for the awards will also be invited as guests for the NSW AIP Branch annual dinner that follows the presentations. These awards have been created to encourage excellence in postgraduate work, and all nominees who participate in the Postgraduate Awards Day will receive a **special certificate** recognising the nominee's high standing.

Students are asked to 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. **See further details below regarding the criteria for the 2018 Postgraduate Awards.**

Members and guests who are unable to attend the **Awards** are invited to join us from 6pm, for the **AGM** and will be followed by a talk by **Tibor G Molnar, Honorary Associate, Department of Philosophy, University of Sydney** be followed in turn by the Branch's Annual Dinner at **Giovanna Restaurant 285 Anzac Parade, Kingsford, Sydney.**

Entrance is FREE to the Awards and Talk by Tibor G Molnar.

Prepared by: Dr Frederick Osman
2018 Awards Convenor

Event Schedule

- *Student presentations* at the **University of New South Wales, School of Physics, Room G59/60, Level G Old Main Building Kensington Campus** – **2.00 to 5.00pm**
- *Refreshments* **- 5.30 to 6.00pm**
- AIP NSW AGM **- 6.00 to 6.20pm**
- Presentation of *Awards and Prizes* **- 6.20 to 6.30pm**
- Guest speaker (*Tibor G Molnar*) – **6.30pm**
- Annual dinner at *Giovanna Restaurant* – **8.00 to 10.00pm**
  Giovanna Restaurant, 285 Anzac Parade, Kingsford, Sydney

2018 Judging Panel

- Dr Scott Martin – **The Australian Institute of Physics New South Wales Branch**
- Tibor G Molnar – **Honorary Associate, Department of Philosophy, University of Sydney**
- Dr Erik Aslaksen **– The Royal Society of New South Wales**

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Criteria for 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 20-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

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2018 Postgraduate Schedule

- ***2.00pm*** **Welcome by Dr Frederick Osman (AIP Awards Coordinator)**
- ***2.10pm*** **Anita PETZLER, Macquarie University, Department of Physics and Astronomy**

  Hydroxyl as a Probe of the Molecular Interstellar Medium
- ***2.35pm*** **Lewis MARTIN, University of Sydney, School of Physics**

  Materials and biology: simulations of peptides, surfaces, and biomaterials
- ***3.00pm*** **Karina HUDSON, University of New South Wales, School of Physics**

  Strange spin properties of semiconductor holes in one-dimensional quantum point contacts
- ***3.25pm*** **Afternoon Tea**
- ***3.50pm*** **Chathura BANDUTUNGA, Australian National University, Research School of Physics**

  Encoding Light: Digital Interferometry for High Precision Optical Metrology
- ***4.15pm*** **Grace CAUSER, University of Wollongong, Department of Physics**

  Physics at the nanoscale: How atoms behaving badly is good news for us
- ***4.40pm*** **Hanh DUONG, University of Technology Sydney, School of Mathematical and Physical Sciences**

  Quantum emitters in hexagonal boron nitride – from two dimensions to zero dimension
- ***5.30pm*** **Refreshments and Networking**
- ***6.00pm*** **Presentation of NSW Community Outreach to Physics Award and AIP NSW Postgraduate Awards**
- ***6.20pm*** **AIP NSW Annual General Meeting (AGM)**
- ***6.30pm*** **2018 Invited Speaker: Tibor G Molnar**
- ***8.00pm*** **Annual Dinner: Giovanna Restaurant, 285 Anzac Parade, Kingsford**

Prepared by: Dr Frederick Osman
2018 Awards Convenor

Hydroxyl as a Probe of the Molecular Interstellar Medium

Anita PETZLER
Department of Physics and Astronomy, Macquarie University

Abstract
The interstellar medium is the collection of gas and dust between the stars of a galaxy and is the raw material from which new stars are formed. Its physical properties as well as a complex set of internal and external influences determine the mass distribution of stars formed. By observing the interstellar medium, we can begin to unravel these complex interactions and build robust models of star formation in galaxies. The interstellar medium consists of atomic gas traced by 1420 MHz hydrogen emission and molecular gas, traditionally traced by 115 GHz carbon monoxide emission.

My research recognises the limitations of carbon monoxide as a tracer of more diffuse molecular gas and employs an alternate tracer: hydroxyl. Hydroxyl is expected to coexist with molecular hydrogen in all environments, including those not well traced by carbon monoxide. The ground state of hydroxyl is split into four levels due to lambda doubling and hyperfine splitting. There are four allowable transitions between those levels at 1612, 1665, 1667 and 1720 MHz. The relative population of hydroxyl molecules in each level is determined by the local gas conditions which in turn determines the relative intensity of absorption or emission. I measure the emission and absorption in the transitions of hydroxyl along sightlines towards bright background continuum sources to determine the local conditions of the intervening hydroxyl gas. Modern observation techniques including large scale surveys using telescopes with unprecedented resolution such as the Square Kilometre Array will give us an overwhelming wealth of data. Therefore, I am developing an automated analysis pipeline that will allow us to quickly extract our target parameters from these observations in a physically and statistically rigorous way. My work will allow us to take full advantage of these remarkable new facilities to complete our understanding of the mechanisms of star formation.

Materials and biology: simulations of peptides, surfaces, and biomaterials

Lewis MARTIN
School of Physics, University of Sydney

Abstract
Biomaterials were originally designed to augment or replace damaged tissue in the body, but now encompass a wider range of applications including drug delivery, cancer vaccines, electronic sensor devices, and non-fouling coatings for ship hulls. At the heart of all of these applications is the interface between synthetic materials and biology. Modern techniques for studying this interface are limited to the macro and micro scales. With the advent of high performance computing clusters, molecular simulation is now capable of simulating the interface at the nano-scale.

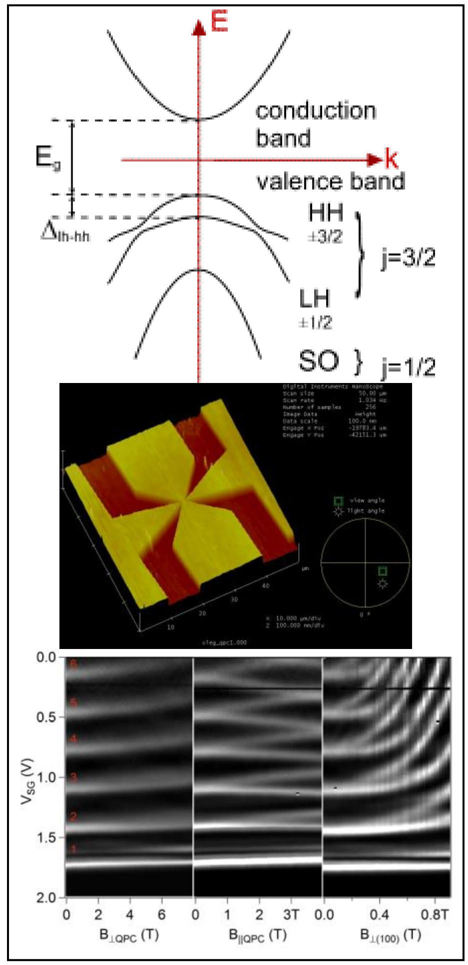
This talk demonstrates how simulation adds important insights to the understanding of biomaterials. It begins with an outline of the theoretical aspects of simulating the interface between water and solid surfaces. After this, computer modelling of small surface-bound biological molecules is used to explain intriguing experimental results showing that they can capture cells on the surface. Finally, a new and practical, scalable technique for controlling biological molecules at the surface is developed. This work advances the field of biomaterials by explaining important processes that occur at the interface of biology and technology.

Strange spin properties of semiconductor holes in one-dimensional quantum point contacts

Karina HUDSON
School of Physics, University of New South Wales

Abstract
Half of all the transistors in a semiconductor chip use holes, yet surprisingly there is much we do not understand about holes. Valence band holes in are spin-3/2 particles, which gives them very different properties to spin-1/2 electrons. There has been growing interest in the use of holes in semiconductor nanostructures for applications from quantum information through to topological super-conductivity. However such applications require a deep understanding of the spin properties of holes.

This talk will describe how a simple problem – the transport of charge in a one dimensional channel [1] – can reveal complex spin physics in hole systems. In quantum wires the interplay of spin-orbit interaction and electrostatic confinement leads to an extreme anisotropy of the Zeeman spin-splitting that is completely unlike electrons.[2] This anisotropy was the opposite of that predicted by theory, and remained a conundrum for over a decade. I will present measurement and theory which finally resolves this mystery, and highlights the use of quantum point contacts as a powerful tool with which to probe the structure of the spin-orbit interaction in hole systems [3,4].



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FLEET ARC CENTRE OF EXCELLENCE IN FUTURE LOW-ENERGY ELECTRONICS TECHNOLOGIES

Prepared by: Dr Frederick Osman
2018 Awards Convenor

Encoding Light: Digital Interferometry for High Precision Optical Metrology

Chathura BANDUTUNGA
Research School of Physics, Australian National University

Abstract
Interferometry has been one of the mainstay techniques of high precision optical metrology. Used in everything from optical coherence tomography to gravitational wave detection, the versatility and range of interferometric techniques has allowed it to be applied broadly across a wide range of disciplines.

In parallel, the past decades have seen substantial development of the communications sector. The explosion in the capabilities of real-time computing and signal processing has been driven by the increasing availability of high performance, field deployable computing hardware.

Combining these two areas, Digital Interferometry uses pseudo random bit sequences to encode, and overlay, an additional layer of optical coherence. In many ways, we can draw parallels from spreadspectrum interferometric techniques, such as optical coherence tomography, however in our case the spread-spectrum being a digitally controlled parameter. When coupled with real-time parallelized decoding architectures this enables selective signal range-gating and multiplexing based on the optical time-of-flight, without compromising the sensitivity of the interferometric readout.

The underlying tenet of Digital Interferometry has always been to ‘pivot from optical complexity to digital signal processing’ and in this talk we will explain the foundational principles of the technique using a novel free-space optical acoustic sensing array. This will lead into a broader discussion on how combining digital signal processing with optical interferometric metrology in this way can inspire the next generation of field deployable sensors that are optically robust, multiplexed, and operate with interferometric precision.

Physics at the nanoscale: How atoms behaving badly is good news for us

Grace CAUSER
School of Physics, University of Wollongong

Abstract
In 1959 Richard Feynman delivered a visionary lecture in which he theorised that if matter could be assembled at the atomic level, then materials could be designed ‘at will’ to exhibit properties which are unobtainable in bulk specimens [1]. Feynman's ideas founded the field of nanoscience and brought the realisation that completely new and tuneable properties could be obtained by manipulating the physical dimensions of matter. Of particular interest within the field of research is the importance of interfaces in communicating low-dimensional phenomena between heterostructure components [2], and which act as anchor points for the direct control and tunability of device functionality.

For my postgraduate studies I investigated the occurrence of magnetic interface phenomena in a range of low-dimensional thin-film systems which have conceivable utility in future condensed-matter devices, namely in the areas of computing and advanced sensing technologies. This talk will discuss one project from these studies which elucidated the fundamental sharpness of magnetic interfaces which can be formed locally by driving magnetic phase transitions in materials using ion beams [3-5]. The investigations are carried out on the intriguing model system - FePt3 - motivated by its unique quantum chemical feature which allows either a paramagnetic or ferromagnetic state to be selected at room temperature depending on the level of atomic-site disorder in the material. By tuning the ion energy and fluence, room-temperature ferromagnetism is locally induced into a fractional volume of a paramagnetic FePt3 film through chemical order modification. The magnetic transition is then investigated through theoretical modelling, and the first density functional theory results for the entire suite of potential long-range magnetically ordered states of FePt3 are presented. By analysing several localised defect structures which may form in FePt3 under ion irradiation, the mechanism of the disorder-driven transition is revealed and shown to be caused by an intermixing of Fe and Pt atoms in anti-site defects above a threshold density.

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Quantum emitters in hexagonal boron nitride – from two dimensions to zero dimension

Hanh DUONG
School of Mathematical and Physical Sciences, University of Technology Sydney

Abstract
Single photon emitters in two dimensional (2D) materials are highly sought after because of their potential applications in quantum nanophotonics and quantum information processing [1]. Recently, 2D van der Waals material hexagonal boron nitride (hBN) has emerged as the first 2D host of ultrabright and photostable quantum emitters [2]. Many efforts have been devoted to fabricating quantum emitters deterministically in hBN. However, these approaches have had limited success, and most require a subsequent high-temperature annealing step that is undesirable for device fabrication [3].

In the first part of our work, we demonstrated the generation of quantum emitters in hBN by using MeV electron irradiation resulting in an elevated density of quantum emitters in hBN with a zero-phonon line distribution spanning 580-720 nm [4]. It is also noteworthy that emitters were generated on flat areas of thin flakes that do not contain grain boundaries or other extended defects. The formation of single photon emitters does not require a following annealing step to activate the emitters thus it is beneficial for integrating emitters into devices.

In the second part, we propose a pathway to generate single photon emitters in hBN quantum dots which are theoretically defined as zero-dimensional materials. Those little structures can have a big effect on a variety of technologies associated with their unique optical and electronic properties. By reducing the size of hBN from hundreds of nanometer flakes down to a few nanometer quantum dots, we can obtain a pure, point-like single photon source with a special size-dependent fluorescent emission. In this way, it is possible for their optical properties to be adjusted according to their purpose of use [5]. The generation of single photon emitters in hBN by electron irradiation would pave the way for hBN emitters to be utilized in various photonic applications, while hBN quantum dots would offer us a chance to learn about interesting physical and optical properties of hBN and how to control its fluorescent emissions for practical applications.

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[2] T. T. Tran, “Quantum Emission from Defects in Single-Crystalline Hexagonal Boron Nitride”. *Phys. Rev. Applied, vol. 5, pp. 034005, 2016.*
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[4] N. M. H. Duong, M. A. P. Nguyen, “Effects of high energy electron irradiation on quantum emitters in hexagonal boron nitride”. *ACS* Appl. Mater. Interfaces, 2018.
[5] S. Zhao, “Single photon emission from graphene quantum dots at room temperature”. Nat. Commun., 3470, 2018.

2018 Invited Speaker

Tibor G Molnar

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Alice and Bob in Wonderland

A presentation at the joint Australian Institute of Physics (NSW) Annual Postgraduate Awards Ceremony and the presentation of the Jak Kelly Prize by the Royal Society of NSW.

(UNSW, 13th November, 2018.)

Like Lewis Carroll's *Wonderland*, our own 'real' world appears to be filled with endless surprises. Wondrous, mysterious, seemingly contradictory affairs await us at every turn. Might we, too, be wandering around down a rabbit-hole?

With ever-more-powerful instruments, we peer further and further into the unknown. What we find is mostly novel, unexpected, surprising. This is what makes Science so interesting – and so exciting – especially in the fields of astronomy, cosmology and quantum physics. It is also what makes Science difficult.

While technologically challenging, performing experiments and making observations is the easy part of scientific research. Describing our observations is even easier: a flash here; a vibration there; and so on. The hard part is *interpreting* what we see – '*making sense*' of the patterns, correlations, invariances and regularities apparent in the data.

Not only is 'making sense' hard; it is, strictly speaking, not even *scientific* – observations/experiments don't come with instructions for how to make sense of them. Rather, 'making sense' is a task for *metaphysics* – something which scientists, and especially physicists, tend to eschew with a passion!

Absent metaphysics, the physicists' tool-of-choice is the so-called "Language of Science": mathematics. Produce the correct mathematical formulation, they say, and all is explained! Well, not so. Mathematics is a powerful tool, but it is not at all suited to the task of 'making sense'. Mathematics can *describe* patterns and correlations, but it cannot tell us what they *mean*. Mathematics can describe relations *between* observations, but it cannot determine what those observations are *of*.

We all expect – nay, insist – that Science help us '*make sense*' of the world; an expectation that contemporary physics is finding increasingly difficult to meet. (There is abundant evidence that even the theorists themselves do not understand their latest theories.)

In this presentation, Tibor Molnar explores this problem of 'making sense', and suggests that a little *metaphysics* – so-called "Analytic Philosophy" – might actually help to achieve it.

Speaker Biography: Tibor Molnar studied Chemical Engineering at UNSW in the 1960s, but then forged a career in IT and business. Retired in 2003, he now pursues a wide range of interests: from physics and neuroscience to AI and philosophy. An Honorary Associate of the Department of Philosophy, University of Sydney, Tibor teaches Philosophy and Science at the university's Centre for Continuing Education and the WEA. A book is also on the way. For Tibor, the pursuit of understanding is the most rewarding of human endeavours, and his enthusiasm for Science in all its forms is well reflected in his presentation style.

Prepared by: Dr Frederick Osman
2018 Awards Convenor