New Zealand Institute of Physics
The institute for professional physicists

NZIP & PHYSIKOS 2023

CONFERENCE | 3 - 5 JULY 2023

Massey University Albany Campus
Auckland, Tāmaki Makaurau

NZIP & PHYSIKOS Conference 2023

Abstract Book

Abstracts – Invited Speakers

Shear-Induced Diamond Formation

Bradby J

Keynote: Jodie Bradby |"Shear-Induced Diamond Formation", July 3, 2023, 9:15 AM - 10:00 AM

Biography:

Jodie Bradby is Head of the Department of Materials Physics at the Research School of Physics at the Australian National University (ANU). She is a condensed matter physicist who works with high-pressures to create new materials in carbon, silicon, and germanium. She is a vocal supporter of women in STEM and is the undergraduate laboratory coordinator for Physics at ANU.
Jodie was awarded her PhD from ANU 2003 before completing a postdoc in the USA as part of an American-Australian Education Fellowship. She returned to the ANU and established a group working on phase transformations in Group 14 elements. She has held a series of Australian Research Council (ARC) Fellowships and in 2019-20 was the President of the Australian Institute of Physics.

Diamond has traditionally been associated with slow geological processes occurring at high temperatures and pressures. Recent studies have found that diamond can also be formed from graphitic carbons at high pressure in minutes at room temperature. The parameter driving this transformation has been suspected to be shear however its clear demonstration has remained elusive. In this work, a combination of high-pressure experiments, electron microscopy and molecular dynamics simulations is employed to understand the structural changes of glassy carbon under both hydrostatic and non-hydrostatic conditions. Glassy carbon demonstrates remarkable resilience with no discernible microstructural changes up to 80 GPa when loaded in a hydrostatic pressure. In stark contrast, non-hydrostatic compression consistently results in the formation of nano-diamonds; evidence that shear strain plays an important role in driving phase transitions in carbon.

Controlling individual atoms using lasers

Andersen M

PUBLIC LECTURE: Mikkel Anderson (University of Otago)- Controlling individual atoms using lasers, July 3, 2023, 7:00 PM - 8:00 PM

Biography:
Mikkel has 20 years experience with research in atomic physics focused on laser manipulation of atoms. His interests range from understanding the intricate workings of the microscopic world to applying this knowledge to develop new quantum technologies.
He received his PhD from the Weizmann Institute of Science in Israel for experimental work on on quantum and classical chaos of atoms trapped by laser beams. He went on to work on a state of ultra-cold matter known as Bose-Einstein condensates with Nobel Laureate Bill Phillips at the National Institute of Standards and technology in USA. After a brief spell at New York University he joined the University of Otago about 15 years ago. At Otago he set up a research programme aimed at controlling and manipulating individual atoms using laser light. This experimental platform became the foundation of his ongoing studies of few-body physics with an unprecedented level of control

Scientists strive to develop techniques to build ever smaller structures. Modern computers and other electronic devices is a direct outcome of this effort, as their performance is facilitated by their micro-chips having feature sizes as small as few nanometers. The ultimate limit of small scale engineering is to build devices using individual atoms.
This talk reveals how we have developed techniques to isolate and control individual atoms using laser beams, down at the University of Otago, here in New Zealand. We will see how we can build individual molecules atom by atom, and how we generate the invisible bond known as quantum entanglement between two atoms. Quantum entanglement makes a measurements on one of the entangled atoms affect the other atom, even when they are at opposite ends of the solar system and no longer in contact. Albert Einstein found quantum entanglement “spooky”, but today it is a well tested phenomena that will power revolutionary technologies in the future.
Additionally, we will discuss an number of the astounding international scientific breakthroughs over the past decades that has facilitated the development of our individual atom manipulation capabilities, as well as what future powerful quantum technologies the research may lead to.

Curriculum Design: Lessons and Opportunities

Farmer S

Virtual Keynote: Stuart Farmer | "Curriculum Design: Lessons and Opportunities", July 4, 2023, 9:15 AM - 10:00 AM

Biography:

Since 2019 Stuart has been the Institute of Physics Scotland's Learning and Skills Manager. Prior to this he taught physics in Scottish secondary school for over 30 years, most of this leading Scotland's largest secondary school physics department.

Throughout his career Stuart has organised and delivered a wide range of teacher professional learning activities not only in Scotland but across the rest of the UK and further afield. He has also been involved in national curriculum and assessment developments and sat on several government advisory committees. He is currently studying part-time for a PhD investigating the alignment of policy and practice of professional learning for Scottish teachers. He has a particular interest in networking and professional learning for potentially isolated teachers working in relatively remote and rural locations. In 2016 he was awarded the Bragg Medal from the Institute of Physics "For outstanding contributions to enhance both the teaching and the public image of physics, making classroom science more relevant, attractive and visible".

In this session Stuart will draw upon his nearly 40 years of experience as a teacher, departmental leader, curriculum and assessment developer, and teacher educator in Scotland, together with his work for the Institute of Physics in the UK and Ireland, to identify some key lessons about the development and implementation of physics curricula in schools. He will draw on his experiences and research to explore the potential gaps between policy and practice and identify potential opportunities and actions to improve the teaching and learning of physics through good curriculum design and teacher professional learning.

Teaching and Assessing for Improved Gender Equity in Physics

Wilson K[1]
[1]UNSW Canberra, Canberra, Australia

Keynote: Kate Wilson | Teaching and Assessing for Improved Gender Equity in Physics, July 4, 2023, 1:00 PM - 2:00 PM

Biography:
Kate is a physicist by training but teaches introductory engineering courses in the School of Engineering and Information Technology at UNSW Canberra, where she is the Director of Undergraduate Studies. She has also designed and taught professional development courses in classroom teaching and course design for early career academics.
For the last 20 years, Kate has been doing research into student learning and student experience in physics and engineering. She has also been looking at gender equity in physics, in particular the role of assessment in maintaining the gender gap in participation in physics. As a past director of the Australian Science Olympiads Physics Program, Kate was involved in improving equity of access to that program without compromising performance at competition. She is also an author of secondary school and first year university physics textbooks, which are informed by her research.

If you're a woman studying or working in physics, then often in classrooms and in meetings you're very much in the minority. In fact, sometimes you're the only woman in the room.
There is a general recognition (although not universal agreement) that the lack of women in physics is not a good thing. It's not a good thing for women because they're being excluded from an important field of human endeavour. It's not a good thing for physics because potentially valuable contributions are being lost, and diversity dividends are being thrown away.
So, what is keeping women out of STEM?
Unfortunately, there are many reasons, and few of them are easy to address as individual educators. But as educators, we can change the way we teach and the way we assess our students to enable more girls/women to continue in physics. And this doesn't have to mean compromising on what we teach, or disadvantaging the boys/men in our classes, or dumbing down our assessments.
It means teaching in ways that better support all learners. It means examining our existing tasks for bias, and then adjusting them appropriately to remove that bias.
This talk will discuss ways to examine your assessment tasks, as well as presenting results from our examination of assessment tasks from the Australian and Indian Physics Olympiad Programs, and our undergraduate physics course. I will also present a short, effective a teaching activity as a model for how we can teach to reduce gender gaps in performance.

Atom-light interactions at ultra-low temperatures

Deb A[1]
[1]University of Otago, Dunedin, New Zealand

Keynote: Amita Deb | Atom-light interactions at ultra-low temperatures, July 5, 2023, 9:15 AM - 10:00 AM

Biography:
Amita Deb is a Senior Research Fellow at the University of Otago. He obtained his doctorate degree from the University of Oxford in Atomic and Laser Physics. He is an experimental physicist specialising in Atomic, molecular and optical physics with a focus in quantum physics and quantum technologies. He works with ultracold atomic gases, especially with Bose-Einstein condensates and degenerate Fermi gases, and study how these atoms interact with each other and with light on a fundamental level. His work has been published in top-ranked journals like Science, Physical Review Letters and Nature Communications, and he holds several patents

The central theme of my talk will be how atoms interact with light and how to explain the well-known effects of attenuation, scattering and phase shift of a light beam passing through matter from an atomic prespective. Quantum mechanical effects can drastically modify the optical response of atoms at ultralow temperatures. Such effects were predicted more than three decades ago, but first experimentally observed only recently [1]. All quantum particles, including atoms, fall in two categories – bosons and fermions, depending on their spin and the kind of quantum statistics they obey. Fermions obey the famous Pauli exclusion principle which is responsible for the electronic structure of atoms. In the context of atom-light interactions in an ensemble of fermionic atoms, Pauli exclusion principle manifests itself as a suppression of light scattering by atoms – effectively making atoms invisible to the light. The opposite is true for bosonic atoms where atoms become more opaque to light. I will give a captivating narrative of the physical principles and the experiments behind these observations.

[1] A.B. Deb and N. Kjærgaard, Observation of Pauli blocking in light scattering from quantum degenerate fermions, Science 374, 972 (2021).

Abstracts – Oral presentations

Satellite Constellations in the MOA Database

Anderson-Baldwin J[1], Rattenbury N[1], Bannister M[2]
[1]University of Auckland, Auckland, New Zealand, [2]University of Canterbury, Christchurch, New Zealand

Biography:
Jasmine's iwi are Tūhoe and Te Arawa. She is an MSc student in the University of Auckland's Physics department as well as a University of Auckland Science Scholars alumnus. Her current research is on the impact of satellites on the Microlensing Observations in Astrophysics (MOA) database. She completed her BSc(Hons) in Physics at the University of Auckland in 2022.

Since 2019 the number of low-Earth orbit satellites has been steadily increasing due to the deployment of large satellite constellations such as Starlink and OneWeb. These LEO satellites leave bright trails across telescope detectors, lowering efficiency and in the worst case introducing systematic errors. There has been growing concern from the astronomy community on how this will impact astronomical observations; particularly vulnerable are wide-field surveys in the optical and near-infrared, such as that carried out by the MOA telescope at Mount John Observatory in Takapō. Other observatories around the world have already reported a marked increase in observations containing satellite streaks, particularly near the horizon and during twilight. I aim to quantify the impact of satellite constellations on the images obtained during the MOA survey. The MOA survey observation data presents a particular challenge to quantify due to the very high stellar density of the Galactic fields it observes. I will present my analysis to date of archival MOA observations over five years from 2018 onward. My analysis returns the number of streak-affected images, the fraction of each image that is affected, and determines how the rate of affected images has changed, and will change, over time. This will lead to a quantification of the loss of “discovery space” in the MOA archive.

Learn Physics while outside. A series of activities to be shared with participants that will help to the learning of physics concepts.

Bhatt K[1]
[1]Nps International School, Singapore, Singapore, [2]NZIP, New Zealand, [3]International Baccalaureate Organisation , Geneva, Switzerland , [4]Cambridge Assessment International Education, UK

Biography:
Kris Bhatt is currently working as Senior Principal at NPS International School, Singapore. He is teaching physics at the IB Diploma level. Before moving to Singapore Kris was principal at Reporoa College in New Zealand and taught physics to NCEA level 1, 2 and 3. Kris also taught physics and mathematics at all 3 levels of NCEA while as Deputy Principal, Curriculum at Rotorua Girls High School.
Kris has taught in India and in the Middle East during his teaching career of 38 years and counting.

Everything that we see around us can be linked to and explained with Physics. Often due to the 'curriculum and how it is presented and delivered' students miss seeing physics around them and its relevance. As a physics teacher over the years, I found that the gadgets that are available for us for class demonstration and practicals are quite expensive and sometimes are not available at all. According to me materials that require to make teaching and learning engaging and enriching should cost less or nothing. In the workshop I will share ideas to make learning recent, relevant, and real. In the workshop I will be sharing simple strategies, tips and techniques that can be used to teach physics concepts across all levels. The strategies will help to promote critical thinking and problem-solving skills in students. I will also provide hands-on tips to teachers to design their lessons on the go, using materials that are in and around them.
In the workshop I will also be sharing activities to help Teachers to teach difficult concepts across topics. In all the activities I will use simple materials that can be found easily and cost less or nothing. The workshop is going to be interactive and participants get to try out the activities during the workshop and also come up with their own.
The workshop will also include assessment techniques and materials to support NCEA physics.

Atoms that avoid each other - counting nodal three-body states

Bradly C[1], Cufar M[1], Brand J[1], Weyland M[2], Andersen M[2]
[1]Massey University, Auckland, New Zealand, [2]Otago University, Dunedin, New Zealand

Biography:

Chris Bradly obtained his PhD from the University of Melbourne in 2015 in Theoretical Condensed Matter Physics for work on few-body physics of ultracold quantum gases. He had a postdoctoral research position in Statistical Physics at the University of Melbourne studying lattice polymer models with Monte Carlo methods and is now a Postdoctoral Fellow in Theoretical and Computational Physics in the New Zealand Institute of Advanced Studies at Massey University (Auckland), Aotearoa New Zealand.

Recent experiments (Weyland et al., PRL 126, 083401 (2021)) of the photoassociation dynamics of two atoms in an optical tweezer trap show two timescales. While most of the atoms form molecules quickly, there is a fraction of cases where the atoms resist the molecule formation for a long time. This striking behaviour is not seen in many-particle experiments where photoassociation forms molecules on a single time scale that depends on the density of the gas. Our hypothesis is that the effect can be explained by the presence of so-called nodal states, and that it should happen for multi-particle states as well. Atoms in a nodal state avoid each other and thus feel the interaction of the photoassociation laser only weakly. In this talk we discuss how to predict the outcome of a three-atom experiment by investigating the nodal eigenstates of a harmonic oscillator.
Typically one could use symmetry arguments for finding nodal states in an isotropic trap, however, this is not a trivial calculation for three bosons in the anisotropic cigar-shaped trap used in the photoassociation experiment. One way to determine if a three-boson state is nodal is to calculate its energy shift under first-order perturbation theory. There, the energy of nodal states will not change as the strength of a contact interaction is increased. We enumerate and count the fraction of nodal states at the energy scales relevant to the photoassociation experiments. We also consider a two-dimensional model. In two dimensions the nodal states generalise the famous Laughlin state, which helped explain the fractional quantum Hall effect in 2D metals in a strong magnetic field.

Nonlinear waves in coupled Bose-Einstein condensates: from false vacuum decay to vortex molecules

Brand J[1], Choudhury S[1]
[1]Massey University, Te Whai Ao – Dodd Walls Centre for Photonic and Quantum Technologies

Biography:
While taking a break from his undergraduate studies in Germany, Joachim fell in love with Aotearoa on a bike-packing trip. After a PhD in Germany and postdoctoral fellowships in the United States and Germany he moved to New Zealand for a lectureship at Massey University. Since 2012 he is Professor of Physics at Massey's New Zealand Institute for Advanced Study. He currently serves as the President of NZIP and as Deputy Director of Te Whai Ao – Dodd-Walls Centre for Photonic and Quantum Technologies.

In the 1970s Sidney Coleman brought up the question: What if the universe we live in is a false vacuum, i.e., a metastable state that could decay at any time? Coleman's theory of false vacuum decay was later used for explaining how the Universe itself came into existence. Obviously, such theories cannot be tested in lab experiments, or can they? In this talk we will explain how the false vacuum decay can be tested on the tabletop with coupled Bose-Einstein condensates in laser-cooled atomic gases. Coupled Bose-Einstein condensates host various interesting nonlinear wave phenomena such as domain walls, oscillons, and vortex molecules. We will also briefly discuss a very recent experiment probing the false vacuum decay.

Electronic and magnetic properties of nitrogen- and boron-doped C60-dimer molecules

Kaur S, Mudahar I, Bubanja V[1]
[1]Measurement Standards Laboratory of New Zealand, Lower Hutt, New Zealand

Biography:

Vladimir Bubanja obtained BSc(Hons) in Physics at the University of Belgrade, Serbia, and PhD in Physics at the Delft University of Technology, the Netherlands. He is a Distinguished Scientist at the Measurement Standards Laboratory of New Zealand, which is NZ's National Metrology Institute embedded in the Innovation Expertise division of Callaghan Innovation, a Crown Agency, and he is an Associate Investigator at the Dodd-Walls Centre for Photonic and Quantum Technologies.

Major advances in industries such as communications, computing, aerospace, and medical during the last several decades have been possible in large part due to the miniaturization of electronics. Devices with individual atoms as active components are the limit of this miniaturization set by the discrete nature of matter. There has been significant recent progress in atomically precise fabrication which enables the development of atom-based devices for use in novel applications that include quantum information processing, quantum materials research, and quantum sensing. At the core of electronics at the atomic scale are device principles based on quantum mechanics. I will describe our recent theoretical work regarding electron transport in nitrogen- and boron-doped C60-dimer molecules.

Modelling Hydrogen Adsorption on Liquid Gallium Alloy Surfaces

Case S[1,2], Ruffman C[1,2], Gaston N[1,2]
[1]The University of Auckland, Auckland, New Zealand, [2]MacDiarmid Institute, Auckland, New Zealand

Biography:
I am a final year BSc student majoring in physics at the University of Auckland. I worked with Dr. Charlie Ruffman on a summer scholarship project last summer investigating hydrogen adsorption on liquid Ga-In. After completing the scholarship, I continued to work with Dr. Charlie Ruffman during a final year reseach project.

Liquid metals have shown great promise as effective catalysts due to their unique behaviour of maintaining metallic electronic properties while existing in a liquid state at near room temperature. For example, Ga-In shows fascinating selectivity changes on melting. The reactivity on Solid Ga-In is dominated by hydrogen evolution, however, when melted, the surface becomes inactive to hydrogen evolution and instead catalyses CO2 reduction to formate with 95% selectivity [1].
However, there exists little understanding as to why Ga-In showcases this selectivity for CO2 reduction. This presentation will discuss our recent computational investigation into the hydrogen adsorption on liquid and solid Ga-In surfaces to examine whether differences in hydrogen binding can explain the changed reactivity.
We used ab initio molecular dynamics to simulate the liquid and solid phases of Ga-In at temperatures of 450 K and 350 K respectively. From this we took snapshots of the simulation and investigated how hydrogen adsorbed to each of the surfaces. We did this by constructing a 0.2 Å resolution grid of adsorption sites above each surface and calculating the adsorption energy at each point. This analysis yielded a 'heat map' of the adsorption energy for hydrogen. From these we can better understand which sites are favourable on the surface in the solid and liquid cases and how hydrogen might diffuse on the surface. From this investigation we gained insight into selectivity in liquid metal catalysts, this will hopefully allow us to better optimise them for important reactions such as CO2 reduction.

[1] Liu, H., Xia, J., Zhang, N., Cheng, H., Bi, W., Zu, X., Chu, W., Wu, H., Wu, C. and Xie, Y., 2021. Solid–liquid phase transition induced electrocatalytic switching from hydrogen evolution to highly selective CO2 reduction. Nature Catalysis, 4(3), pp.202-211.

Teaching approaches using AP Physics

Chrystall S[1]
[1]Saudi Aramco College Preparatory Center, Dhahran, Saudi Arabia

Biography:
After teaching Physics for 20+ years in New Zealand, 2 years working as a content developer for the Science Learning Hub writing resources on Rockets, Satellites and Cycling Aerodynamics, and serving time for NZQA as a National Assessment Moderator for physics, I moved to Saudi Arabia. I have been teaching Advanced Placement Physics to Saudi students there for 7 years now. These students have finished high school and are completing a foundation year program before they embark on engineering degrees at universities mainly in UK, US and Australia. I greatly enjoy teaching students and helping them to enjoy their learning.

Seven years ago, I left the delights of NCEA Physics and began teaching the Advanced Placement (AP) Physics - Mechanics C course to Saudi Students in Saudi Arabia. This is a first-year university level calculus-based course with a lab-based component and a significant emphasis on complex problem solving as well as integrating physics concepts from different content areas into free response questions.
My physics thinking and problem-solving strategies have been significantly developed, challenged and tightened up while teaching this course. It has certainly been refreshing for me to return to teaching physics with deep understanding and complex problem solving in a range of contexts and question types we don't appear to commonly use in New Zealand. I will share some of the teaching approaches I have developed to help my students prepare for this international exam. I will also share some of the many resources that may be of use in your lessons.
In this presentation I will share parts of my journey of preparing students for this demanding and satisfying course. Even if not enrolling for the International AP Physics Exam, which in itself may be a viable option for you and your students, there are many aspects of this course and some of the teaching approaches used that may be of value in your physics lessons.

The Process of Science

Currie C[1]
[1]Palmerston North Boys' High School, Palmerston North, New Zealand

Introducing the Perimeter Institute resources for secondary school students, designed to help you explain a range of important physics and science concepts: How do scientists think? Students will think like scientists as they collaborate together and communicate in creative ways to answer curiosity-driven questions. The classroom kit provides teachers with print and digital resources to inspire students to explore the habits of mind that scientists practice through hands-on activities that encourage them to be curious, creative, and collaborative.

Big science from a little country

Easther R[1]
[1]The University of Auckland, Auckland, New Zealand

Physics and astronomy are at the forefront of “big science” — branches of knowledge whose development relies on large, shared research facilities. Two examples of this are the European Space Agency’s LISA mission which is slated for launch in the early 2030s, and the Legacy Survey of Space and Time - or LSST - which is currently getting underway at the new Vera Rubin Observatory.   New Zealand scientists are contributing to both LISA and the LSST. I will briefly discuss how little countries like New Zealand can contribute to big projects, how we can get involved, and what we get out of it.

Ultrashort pulses and optical frequency combs in laser-driven nonlinear resonators

Erkintalo M[1]
[1]The University of Auckland, Auckland, New Zealand

Biography:
Miro Erkintalo obtained the degrees of BSc, MSc, and PhD from the Tampere University of Technology in Finland in March 2009, October 2009, and February 2012, respectively. After obtaining his doctorate, Miro joined the University of Auckland as a post-doctoral fellow in 2012, and has work in various positions in that institution ever since. At the moment, Miro is an associate professor in physics, with research specialty in the field of nonlinear photonics. He is the recipient of the 2019 New Zealand Prime Minister's Emerging Scientist Prize.

The ability to generate ultrashort pulses of light in coherently driven nonlinear optical resonators arguably represents one of the most significant advances in photonics research over the past decade. In the spectral domain, these pulses correspond to coherent "optical frequency combs" that have enabled groundbreaking applications in fields ranging from telecommunications and precision spectroscopy to optical distance measurements and detection of extrasolar planets. From a fundamental vantage, the pulses correspond to dissipative "cavity" solitons -- localized dissipative structures that are able to maintain constant shape and energy through a double-balance between nonlinearity and dispersion on the one hand, and dissipation and energy gain on the other hand. The canonical physics that describe dissipative soliton generation in coherently driven resonators is well understood. However, higher-order effects and more sophisticated system configurations continue to draw substantial research interest, both from the perspectives of fundamental nonlinear dynamics and possibilities for improved applications. In this presentation, we will review the basic physics and applications of solitons that can manifest themselves in externally driven resonators, and describe recent discoveries of qualitatively new types of solitons in systems that embrace higher-order effects. Specifically, we will discuss how stimulated Raman scattering can allow for the generation of pulses with record-short durations, and how the use of two lasers with different carrier frequencies can enable a new route for so-called parametrically-driven cavity solitons.

Radiation-induced creep through dislocation motion in nano-crystalline alloys

Firman Dimanstein N[1]
[1]Hebrew University Jerusalem, Jerusalem, Israel

Biography:
Education: B.Sc. in the Combined Program in Exact Sciences – Physics Emphasis and M.Sc. in Physics from the Hebrew University of Jerusalem.
Awards: The combined program in exact sciences scholarship for outstanding students and Ashkol scholarship in nuclear physics (Israel Ministry of science, technology and space)
Now: PhD candidate at the Hebrew University of Jerusalem

One main factor limiting structural material's lifetime is deformation due to creep. This failure mechanism is strengthened when the materials are exposed to radiation, and creep is enhanced [1]. While the mechanism controlling creep varies, irradiation-induced creep is controlled by interactions of dislocations with point defects that are at super-saturation due to the irradiation. A prominent approach for reducing irradiation-induced creep in structural materials is the integration of precipitates within the material's microstructure. The matrix-precipitate interface traps point defects, and thus prevents point defect-dislocation interaction. Along these lines, it was suggested to employ nanocrystalline alloys as radiation-resistant material, where small grain size prevents dislocation reactions and the high availability of interfaces serves to trap point defects. However, it was shown that grain boundary related relaxation due to point defect interactions at the nanocrystalline alloys grain boundary does lead to significant creep rates [2, 3].
Irradiation-induced creep is simulated using molecular dynamics in a range of dilute Cu alloys: nano-crystalline Cu-V, Cu-Ta and Cu-Nb. The variation in observed local dynamics due to sample composition and its correlation with resulting macroscopic creep rates serve to identify the creep controlling mechanism. We show that the highest correlation between observed creep rates and specific displacement mechanism holds for the motion of stair-rod dislocations near the grain boundary. These correlate well with triple junction migration that controls creep.

1. G. Was, “Fundamentals of Radiation Materials Science: Metals and Alloys”, Springer, Berlin, 2007
2. Y. Ashkenazy; R. S. Averback, Nano letters, 4084-4088, 2012
3. K.Tai; R. S. Averback; P. Bellon; Y. Ashkenazy, Scr. Mater., 65, 163, 2011.
4. K.Tai; R. S. Averback; P. Bellon; Y. Ashkenazy; B. J. Stumphy, Journal of Nuclear Materials, 422, 8, 2012.

Flat Band Physics: Making and Controlling Compactly Localized Waves

Flach S[1]
[1]Institute For Basic Science, Daejeon, South Korea

Biography:
Since 2017 Honorary Research Fellow, New Zealand Institute for Advanced Study
Since 2015 Professor, University of Science and Technology, Daejeon
Since 2014 Director of Research Center, Institute for Basic Science, Daejeon
2012-2016 Professor, New Zealand Institute for Advanced Study, Massey University
1997-2012 Head Visitors Program, MPI for the Physics of Complex Systems, Dresden
1994-1997 Guest Scientist, MPI for the Physics of Complex Systems, Dresden
1992-1994 Postdoc, Boston University
1991-1991 Fellow, Alexander von Humboldt Stiftung, TU München
1988-1992 Research Assistant, TU Dresden

Certain lattice wave systems in translationally invariant settings have one or more spectral bands that are strictly flat or independent of momentum in the tight binding approximation, arising from either internal symmetries or fine-tuned coupling. Such flat bands (FB) exist because the lattice waves can arrange in compact localized states (CLS). Localization is unusual since the underlying equations are translationally invariant. Compactness is even more unusual - it means that the wave excitation strictly vanishes outside some finite volume. This happens because the fine-tuned coupling satisfies exact destructive interference conditions. That destructive interference makes compact localization possible.
I will review the basic properties of FBs and CLS including a number of prominent experimental observations. I will then discuss ways to control the CLS properties by tiny modifications of the underlying system. I will also show how the CLS concept can be extended to nonlinear media, and how FBs respond to adding disorder and quantum many particle interactions.

Women in Engineering: teacher input into outreach activities

Fox A[1], Stevens N[1], Kularatna-Abeywardana D[1]
[1]University Of Auckland, Auckland, New Zealand

Biography:
Ashleigh has previously worked in analytical laboratories, as a crime scene technician and then moved into the tertiary sector. She has an extensive history in science communication and outreach, and now manages a long-term project at the University of Auckland, to increase the number of women studying Engineering.

The Women in Engineering Project at UoA has been in place for just over 4 years now. Within our portfolio of initiatives, our amazing female engineering students bring hands-on activities to school classes, work through them with the students and answer all their questions to help them understand what engineering is. We have been working on new material over the summer, and would love to get teachers' feedback on these activities to refine them for use in our outreach program.

Teachers are well-placed to be a positive influence on students' perception of STEM subjects and their career decision-making early on in the process. This is particularly important for women students, who are very likely to be discouraged to continue studying physics through high school. We want to support teachers to demystify engineering, embed engineering applications of science concepts into classroom teaching and showcase relatable role models to help inspire school students to consider this career path. One of the future goals of the WIE project is to engage with teachers through professional development and to allow you to add interest, variety and excitement to your classroom in the way that you choose.

This workshop will be your opportunity to help us understand what resources teachers need to give students a wider understanding of the connection between maths, science and engineering, to gain some hands on experience with these concepts, and demonstrate the real world applications of what they learn in class.

Promoting gender equity in STEM education: The Women in Engineering Project

Fox A[1], Stevens N[1]
[1]University of Auckland, Auckland, New Zealand

Biography:
Ashleigh has previously worked as a technician in analytical laboratories and as a crime scene technician, before moving into the tertiary sector. She managed the Anthropology laboratories and outreach activities in the Faculty of Arts, as well as running her own Family Science Workshops. She has an extensive history in science communication and outreach, and now leads a long-term strategic project to increase the number of women studying Engineering at the University of Auckland.

It is clear that gender equity and diversity in STEM sectors is still sadly lacking, and it is equally clear that the decline in numbers of women studying subjects such as Physics starts happening very early in the school-university-industry pipeline. This means that teachers are well-placed to be a positive influence on students' perception of STEM subjects and their career decision-making.
Physics is a challenging subject for many female students to find a personal connection to, or to see a career pathway from, but it is a crucial tool for a budding engineer to possess. How do we keep this subject appealing and accessible to young women, and break down the stereotypes that still exist? Organisations like ours have spent years on deliberate and well-resourced efforts into promoting women in STEM in general, and engineering in particular. What has or has not worked in that time? What impacts have been made? What else do we still need to do?
The WIE project has added a number of women-focused initiatives into the faculty outreach and recruitment portfolio, but there is much more work to still be done to encourage women students through the engineering door.
We reflect on the last 4 years of the UoA Women in Engineering Project and open the discussion on what is needed to catalyse the next step-change for increasing gender diversity in Engineering.

A New Model of Galactic Atomic Hydrogen for Improved Analysis of Diffuse Gamma-Ray Emission from the Inner Galaxy with Implications for the Galactic Center Excess

Gordon C[1], Pohl M, Macias O, Coleman P
[1]University of Canterbury

Biography:
Dr Chris Gordon is a Senior Lecturer at the School of Physical and Chemical Sciences at the University of Canterbury. His research interests are in astrophysics and cosmology. He is particularly interested in finding non-gravitational evidence for dark matter.

We present a new model of Galactic atomic hydrogen that provides distance resolution for lines of sight toward the Galactic Center. This model is based on explicit radiation-transport modelling of line and continuum emission and a gas-flow model in the barred Galaxy. We apply this new model to analyse the diffuse gamma-ray emission from the inner Galaxy. Our results show an improved fit to the observed gamma-ray emission with high significance when our new atomic hydrogen model is used to estimate the cosmic-ray-induced diffuse gamma-ray emission. However, we still require a nuclear bulge at high significance. Once this is included, there is no evidence for a dark-matter signal, be it cuspy or cored. But an additional so-called boxy bulge is still favoured by the data. Our findings are relevant to understanding the so-called Galactic Center Excess."

Magnetic memories for superconducting electronics and quantum computers

Granville S[1, 2]
[1]Robinson Research Institute, Victoria University of Wellington, New Zealand, [2]MacDiarmid Institute for Advanced Materials and Nanotechnology, New Zealand,

Biography:
Dr Simon Granville is a Senior Scientist at the Robinson Research Institute of Victoria University of Wellington in New Zealand and a Principal Investigator of the MacDiarmid Institute for Advanced Materials and Nanotechnology. He is an experimental materials physicist working on magnetic materials and devices, especially thin film rare earth nitrides and Heusler alloys. His current projects include developing energy-efficient, ultra-high-speed and high-performance magnetic memory and logic for superconducting computing; spintronic sources of THz waves; and magnetic sensors for monitoring infrastructure. He also investigates the spintronic and spin caloritronic properties of ferromagnetic Weyl semi-metal thin films and devices.

At current trends, energy use for computing will reach 40% of the world's electricity production and 10% of all the world's energy production, by the early 2030s [1,2]. Even if existing transistor-based processing continues to improve as the Si technology base approaches long-touted physical limits, it will soon be imperative to change to a less energy-intensive form of computing.
Cryogenic computing based on superconductors could provide a solution for replacing the most energy-intensive data centres and cloud computing facilities [3]. However, there is no type of memory operable at cryogenic temperatures that can make superconducting computing realistic.
In this talk I will describe how our research into devices made from thin film rare-earth nitrides can solve the problem of memory for scalable superconducting logic. The rare-earth nitrides are magnetic semiconductors with an unparalleled potential for adjusting both their electrical conductivity and magnetic coercivity to match the tough requirements of cryogenic memories. I will introduce the types of devices we are producing that will mean energy-efficient superconducting electronics can be made at the scales needed for realistic quantum computers.

[1] Decadal Plan for Semiconductors, Semiconductor Research Corporation (2021) https://www.src.org/about/decadal-plan/
[2] D. Natelson, The need for energy-efficient computing [blog post] (2022, November 15)
[3] D. S. Holmes et al., Computer 48, 34 (2015).

Physics in Construction: Some examples and contexts

Henderson H[1]
[1]Whangārei Boys' High School, Whangarei, New Zealand

Biography:
Haggis is "of the four winds". Born on an army base, he has moved around and has now settled at Mangapai, where he is fulfilling his dream of growing his own firewood. He teaches Physics and Te Reo and he enjoys teaching kids, tinkering in his shed, patting his cat, walking his dog, and looking at the night sky. He loves his family, folk music, and the quest to understand the rules that govern the universe – Physics, in other words. He is particularly fond of the smell of macrocarpa firewood and dark ale – often at the same time.

Very few of our Physics students will become research Physicists. Most will use the knowledge in an applied sense to solve problems for people, often in engineering or health. Because of this, it is useful to have lots of teaching contexts from some of these industries and many teachers use them already. For example, the 6-hour half-life of Technetium 99 as a tracer in cancer diagnosis work. Before becoming a teacher, I worked in the construction industry as a crane driver and then, after completing my degree in engineering, as a geotechnical engineer. A range of applications in Physics, mostly mechanics, will be presented in a way that will help boost the applicability (and thus the relevance) of the core ideas to students who are aware of possible future industries and employment areas.

Sustainable energy: illustrating the connections to high school physics and career opportunities for physics students

Jack M[1], Abeynaike A[1], Lowrey S[1]
[1]University of Otago, Dunedin, New Zealand

Biography:
Michael Jack is an Associate Professor and Director of the Energy Programme in the Physics Department at the University of Otago. He began his research career in the areas of quantum optics and quantum degenerate gases, but for the last 15 years he has carried out research in a range of different areas of sustainable energy. Current research interests include understanding patterns of electricity use and how energy efficiency and new technologies might influence these patterns, and how flexibility in energy end use might enable greater uptake of variable renewable supply.

Applications of physics occur throughout the science and engineering of sustainable energy, including renewable energy resources and technologies and energy efficiency. Emphasising these applications and the resulting career pathways could provide motivation for many high school physics students. In the Department of Physics at the University of Otago we have a long-running (>20 years) Bachelor of Science programme that teaches students the applied physics behind sustainable energy. In this workshop, using some of the content from our courses, we will illustrate the simple physics behind many renewable energy technologies and connect these examples to the high school curriculum. We will also discuss the types of university students these courses attract, including a disproportionate number of female students, and the range of possible sustainable energy career opportunities available for graduates, including, renewable energy engineering, electricity system modelling and data science and energy and carbon consultancy.

Supporting teaching Physics by non-physics specialists

Jackson K[1]
[1]Wakatipu High School, Queenstown, New Zealand

Biography:
Kate Jackson, Physics teacher at Wakatipu High School and NZIP regional facilitator for Central Otago and the surrounding areas.

This workshop is intended to collect and share good practice in physics teaching. With an increasing number of non-physics graduates teaching Physics (myself included) and limited information on what should be taught, this workshop has two main aims. Firstly, to open up the discussion about what matters to Physics teaching and what doesn’t and secondly to collate this information for sharing in Term 3 and beyond. If you are an experienced physics teacher please come along with your top 5 tips, ideas and thoughts on what the priorities for new folk should be. And if you're new, come along to ask questions, feed forward your thoughts and share your experiences.

Scintillation materials from glass: advantages and applications

Kaewkhao J
[1]Nakhon Pathom Rajabhat University

Nowadays, glasses doped with Lanthanide ions (Ln3+) can be developed as scintillation material because of high emission efficiencies, corresponding to 4f–4f and 4f–5d electronic transitions of the Ln3+. The sharp emission spectra from the UV to the IR region are obtained, from 4f–4f transition, because of their shielding effects of the outer 5s and 5p orbitals on the 4f electrons. In case of 4f–5d transition of Ce3+ shows very fast timing respond behavior and Ce3+/Ce4+ concentration and ratio are also key for enhancement of scintillation intensity. Since the Ce3+ emission is strongly affected by the ligands and crystal field, especially on d level. The energy levels of an Ce3+ ion in crystal filed effect can be varied (split) and different from free ion. The difference in energy between the 5d and 4f levels of free Ce3+ ions is in the UV region, whereas for Ce3+ ions in a crystal, this energy difference can be varied from UV to the lower energy visible region, depending on the crystal field. From this reason, emission wavelengths can be varied in different host.

In this presentation, Lanthanide ions doped scintillating glasses have been reviewed. Scintillation and luminescence and properties of the glasses doped with several lanthanide ions have been explained. Moreover, the status of their potential applications for scintillation material from glasses are also given.

Optical physics and the future of metrology

Koo A[1], Fung Y[1]
[1]Measurement Standards Laboratory of New Zealand

Biography:
Annette completed a physics PhD through Victoria University of Wellington in 2005 and then spent 3 years in Melbourne as a postdoctoral fellow at CSIRO and then at Monash University doing research into catalysts for solar hydrogen generation.
In 2008 she started at MSL as a research scientist, developing expertise in the measurement of light and human perception, including the design of MSL's robot-based goniospectrophotometer and ensuring the equivalence of transmittance scales worldwide.
Since late 2021 Annette has been the Chief Metrologist for MSL.

Since the redefinition of the metre in terms of the speed of light in 1983, optical methods have been fundamental to our ability to make accurate dimensional measurements. And as our ability to control and sense the interaction of matter and light increases, we are finding that other quantities such as mass, time, pressure, electric field, gravity, temperature, and trace gases can be probed, pushing at our current measurement limits. In this presentation we will look at some of the impacts that optical physics techniques are having in the world of metrology and the challenges that still remain.

Humidity calibrations, definitions and reference functions: some issues associated with calibration of humidity sensors.

Lovell-Smith J[1]
[1]Measurement Standards Laboratory of New Zealand, Lower Hutt, New Zealand

Biography:
Jeremy Lovell-Smith gained a BSc(Hons) in Psychology at Canterbury University in 1976. After a little travel and bewilderment he spent a year at Teacher College and then taught Maths, Physics and Science at Tararua College for three years before returning to Canterbury University to complete BSc(Hons) in Physics and a PhD in Chemical and Process Engineering (working on techniques to measure moisture profiles in drying concrete slabs), while working on his Daisy Farm, relieving teaching, getting married and having children. He joined MSL in 1997 in order to establish the National Humidity Standard. He has been there pottering ever since.

The NZ Humidity Standard, established at the Measurement Standards Laboratory (MSL) in 2000, is based on several physically-characterised primary-standard humidity-generators operating on two-pressure (2-P) and two-temperature (2-T) principles. These generators are used to calibrate dew point and relative humidity hygrometers for a wide range of users including in the educational, industrial, research, health, transport, storage and meteorological sectors.
The dew-point temperature, Td, scale, in the range from -70 °C to 95 °C, is realised as the known output of the generators which saturate a stream of air at a known temperature, Ts, and pressure, ps, and then deliver it to a dew-point hygrometer sensor at a known pressure, pd. The relative humidity,ψ, scale, from near 0 %rh to near 100 %rh, is realised when the conditioned air is passed into a temperature-controlled chamber held at temperature Tc and pressure pc. Calculation of the reference Td and ψ enable calibration of dew-point hygrometers (including chilled mirror hygrometers) and relative humidity hygrometers to be traceably calibrated. This requires transducers used for measuring Ts ps, pd and Tc to be calibrated, the errors associated with the measurements, humidity reference equations and calculations to be well understood, and a corresponding uncertainty budget accounting for the potential error in the reference value to be constructed.
Drivers for research in metrology include the continual need to appraise our methods, to identify and reduce error, and to identify and rectify inconsistencies in our understanding, representation and ability to calculate values of physical quantities.
In this paper, we outline some of the problems associated with calibration of hygrometers that we have encountered including (a) the definition of relative humidity, $\psi = \psi(x,T,p)$ which has suffered from non-uniqueness (many different definitions) and a general inability (for most definitions in common use) to cover the full range over which relative humidity sensors measure,
(b) weaknesses in the definition of empirical reference functions for calculation of the saturation water vapour pressure, $e = e(T; a)$, and of the water vapour enhancement factor $f = f(T,p;b)$. Here x, T and p are the air vapour mole faction, temperature and pressure respectively, and a and b are vectors representing the parameters of the equations for e and f respectively,
(c) the surprisingly difficult measurement of air temperature, and
(d) the slow and hysteretic response of relative humidity sensors.

Internship and PhD Research Opportunities at SOKENDAI and Inter-University Research Institutes in Japan

Mayama S[1]
[1]The Graduate University For Advanced Studies, Sokendai, Shonan Village, Hayama, Miura, JAPAN

Biography:

Satoshi Mayama is a lecturer at The Graduate University for Advanced Studies, SOKENDAI. He obtained a Bachelor and Master degree from the Faculty of Science and Engineering at Waseda University. He then moved to Hawaii to conduct astronomical research at National Astronomical Observatory of Japan during his PhD study at SOKENDAI. Since 2009, he has worked at SOKENDAI HQ as an assistant professor and is currently a lecturer. He is also in charge of international relations of the University.

SOKENDAI (The Graduate University for Advanced Studies) is the national university that exclusively offers doctoral programs in Japan. The concept of SOKENDAI is unique in the world, whereby it is a university that is affiliated with 20 Inter-University Research Institutes (IURIs). These IURIs are world-class research institutes in Japan. For example, the Japan Aerospace Exploration Agency (JAXA)2, the High Energy Accelerator Research Organization (KEK)3, the National Institute for Fusion Science4, Showa station in Antarctica5, and so on are part of the SOKENDAI campus. Most SOKENDAI professors and students work on their research and study as members of these IURIs.
In this talk, I will introduce SOKENDAI and the IURIs' research activities. More importantly, I will highlight the internship programs, facilities, and various financial support that are available to students, postdocs and professors from New Zealand. As expected, SOKENDAI welcomes international collaboration from students and faculties.

2) https://www.isas.jaxa.jp/en/
3) https://www.kek.jp/en/
4) https://www.nifs.ac.jp/en/
5) https://www.nipr.ac.jp/english/

Teaching energy using energy bar charts

McGovern M [1]
[1]Havelock North High School, Hastings, New Zealand

Biography:
Matthew McGovern is a high school physics teacher in Havelock North.
He was lucky enough to travel some years ago to Arizona to do a Physics Education course in 2017, and ever since has been passionate about bringing ideas from the Physics Education literature to his classroom, and also sharing with other physics teachers to improve their practice, and make their classrooms more enjoyable.

What exactly is energy?
Energy is certainly an abstract and hard to pin down concept for teachers, let alone students. Along with it's abstractness, students need to be able to deal with vocabulary to describe energy (that has often been muddled in everyday speech), they have to move between different representations of energy (words, pictorial and algebraic), and they have deal with experts (teachers) who can move between different ontologies for energy without realising it.
Teachers see the principle of conservation of energy as obvious and elementary, but students can easily misunderstand this idea as they are trying to juggle formula and calculations.
Energy bar charts allow students to master their understanding of conservation of energy in a number of examples, before they move on to doing more rigorous calculations. This reduces their cognitive load, and hopefully increases the chance of them understanding both the concept, and the procedures associated with the principle of conservation of energy.
This hands-on workshop will attempt to allow teachers to see these confusions about energy through their student's eyes as they are taught to model energy using energy bar charts on mini whiteboards.

Physics teaching: a dying career?

McGovern M[1]
[1]Havelock North High School, Hastings, New Zealand

Biography:
Matthew McGovern is a high school physics teacher in Havelock North.
He was lucky enough to travel some years ago to Arizona to do a Physics Education course in 2017, and ever since has been passionate about bringing ideas from the Physics Education literature to his classroom, and also sharing with other physics teachers to improve their practice and make their classrooms more enjoyable.

In this talk I will discuss how the current trend of fewer and fewer physics teachers being trained has ramifications for students, teachers, and career physicists.
Furthermore, I wish to discuss how our current training of new physics teachers (whether they be new graduates or out-of-field teachers who are becoming physics teachers) is inadequate and needs reform.
This talk will go through the pros and cons of a proposed summer school to meet the needs of our physics teachers. I will detail similar initiatives overseas and summarise what the literature says about creating expert physics teachers.
By the end of this talk I hope to have convinced attendees that physics content knowledge and physics pedagogical content knowledge are different skill sets, both of which a good physics teacher must master, and how the proposed summer school hopes to address all these aspects.

Bidirectional Reflectance Distribution Function Measurements and Uncertainties

Molloy E[1]
[1]Measurement Standards Laboratory, Lower Hutt, New Zealand

Biography:
Ellie has submitted her PhD thesis working on the metrology of scattering distributions at MSL.

We make judgements every day based on the light scattered by surfaces around us. Should I eat it? How much would I pay for it? Is it real? These decisions are made based on the different ways that the surfaces reflect the incident light. One of the quantities that can be used to help describe the appearance of an object is the bidirectional reflectance distribution function (BRDF), which completely describes the reflection of the light from the surface of a material. BRDF measurements are of interest in various industries, including automotive, cosmetic, and computer graphics. Quality control is important to these industries because visual effects are known to influence a customer's judgement of the quality and acceptability of manufactured products. Measurements of BRDF are also required for radiometric and photometric instruments including optical sensors on satellites that are used for remote sensing and tracking of more than half of the essential climate variables. To deliver effective climate policy, it is essential to ensure that information and data collected from observations of our climate is as accurate as possible.
Therefore, it is important that industries have access to measurements of BRDF that are metrologically traceable. Measurements are traceable if they can be linked back to the SI definition through an unbroken link of calibrations, each contributing to the measurement uncertainty. Traceability ensures that measurements made in different places at different times can be meaningfully compared because each measurement is being made relative to the same definition. This talk will describe the process of making traceable measurements of BRDF. This will include describing the instrument used to make the measurements and the development of a measurement model to describe the relationship between the BRDF and all the input quantities that might influence the measurements in order to estimate the measurement uncertainty. Measurements made at MSL will be compared to those made at other labs around the world to test the equivalence of our measurements.

Gamefying Physics Concepts. Exploring how a simple card game has revolutionized a teacher's attempt to assist students in linking concepts.

Morgan J[1]
[1]C/O St Peters School Cambridge, Cambridge, New Zealand

Biography:
Director of eLearning
Twice nominated Science Educator of the year

Have you played last card, UNO. will this 2 am revelation has enabled my classes in Junior Physics and Year 11 Physics has changed how my student interact with equations, concepts, and connections in Physics.
Students must link ideas between cards in their hand and the upturned card. Students challenge other students to demonstrate connections. See how a 15-minute gamification lesson may engage and assist your students.

Interacting with AI's in a Physics Classroom. More than a word bot.

Morgan J[1]
[1]St Peters School Cambridge, Cambridge, New Zealand

Biography:
Director of eLearning
Kudos SCience Educator of the year (Twice nominated)

Ai's like CHAT GPT has taken education by storm. This talk will explore how these AI's can add value to your lessons, engage students with their learning and become a tool for further development. THe talk will demonstrate how AI's have been used successfully and unsuccessfully in classes, and share prompts and tricks that they have found.

Simple Electrical Circuits. Using a visual approach for students who lack strong numerical skills. Uses a digital platform but can also be done on paper.

Morgan J[1]
[1] St Peters School Cambridge, Cambridge, New Zealand

Biography:
Director of Elearning
Twice nominated Science educator of the ear (Kudos awards)

Many students struggle to understand the relationships between Current Voltage and Resistance in simple series and parallel circuits. The students who struggle the greatest are those who are numerically disadvantaged. This visual tool allows students to observe and see the effects of changing resistance on simple series and parallel circuits and better construct written answers.

Massive enhancement of the NaMgF3:Sm nanoparticle photoluminescence by 2-thenoyltrifluoroacetone

Nalumaga H[1], Schuyt J[2], Williams G[1], Chong S[2]
[1]MacDiarmid Institute of Advanced Materials and Nanotechnology, Victoria University Of Wellington, Wellington, New Zealand, [2]Robinson Research Institute, School of Engineering, Victoria University of Wellington, Wellington, New Zealand

Biography:
Hellen Nalumaga is a Postdoctoral Research Fellow affiliated with MacDiarmid Institute for Advanced Materials and Nanotechnology. Her research focuses on the properties of multifunctional nanostructures for optics-based devices, and the development of complex oxide heterostructures for superconducting switching.

Bulk lanthanide (Ln) ion doped NaMgF3 has been reported to exhibit luminescent properties suitable for X-ray dosimetry1, and optics-based temperature sensing up to 450 K2. However, the absorptions and emissions of trivalent Ln ions, such as Sm3+, are weak due to the parity-forbidden nature of the 4fn → 4fn transitions involved that limits the minimum detectable dose and temperature resolution. One method to increase the optical transition probabilities is to use nanoparticles sensitised with organic ligands3. Using nanoparticles is also advantageous due to the reduced light scattering that occurs allowing for arbitrary shaped transparent nanoparticle composites to be made that include 2D dosimeters and fibre optic temperature sensors. The major challenge in Ln ion photoluminescence sensitisation is to find a suitable ligand with a triplet energy level that is at an optimal energy difference above a suitable Ln ion excited state.
In this talk, we present the successful sensitisation of Sm3+ photoluminescence by 2-thenoytrifluoroacetone (TTFA). Oleic acid-capped NaMgF3:1%Sm nanoparticles were initially synthesised using the hydrothermal technique. Subsequent ligand exchange was carried out using TTFA to form a NaMgF3:1%Sm(TTFA)3(H2O)2 complex. Results from photoluminescence studies demonstrated an >244,000% enhancement in the emission intensity of the hypersensitive Sm3+ 4G5/2 → 6H9/2 transition. The TTFA → Sm3+ energy transfer process occurred through the "antenna effect", where the TTFA molecule was excited from the singlet ground state, S0, to the excited singlet state, S1, on UV absorption. This was followed by intersystem crossing from S1 to the TTFA triplet state T1, from where energy transfer occurred to the resonance energy levels of Sm3+, hence yielding Sm3+ emissions.

References:
1. Williams, G. V. M., Schuyt, J. J., & Madathiparambil, A. S. (2018). The effect of Mn concentration on the luminescence properties of NaMgF3:Mn: defect/Mn complex photoluminescence, radioluminescence, and optically stimulated luminescence for radiation dose monitoring. Optical Materials, 84, 763-770.
2. Schuyt, J. J., & Williams, G. V. M. (2019). Quenching of the Sm2+ luminescence in NaMgF3:Sm via photothermal ionization: Alternative method to determine divalent lanthanide trap depths. Applied Physics Letters, 115(18), 181104.
3. Nalumaga, H., Schuyt, J. J., & Williams, G. Sensitisation of Eu3+ Photoluminescence in NamgF3: Eu Nanoparticles Using 2-Thenoyltrifluoroacetone. Available at SSRN 4384384.

Physics Assessment from NZQA's perspective

Neal R[1], Snelling R[1]
[1]NZQA

NZQA will present a short workshop for teachers relating to both external and internal NCEA assessment. Participants will be able to gain an insight into current NCEA assessment methods in physics.

Programming in Secondary Physics

Pahl E[1], O'Hanlon T[1]
[1]University of Auckland, Auckland, New Zealand

Biography:
Dr Elke Pahl is a Senior Lecturer in Physics at the University of Auckland whose research focusses on the modelling of material properties under normal conditions and in extreme environments. She has created a number of Programming in Python (PiP) labs used in first year Physics.
Tristan O'Hanlon is a Professional Teaching Fellow in Physics at the University of Auckland and has implemented programming skills sessions in the training of beginning science and physics teachers.

This workshop will walk through some interactive numerical programming activities, suitable for senior secondary physics students, that can help contextualise and visualise topics such as kinematics and projectile motion. These activities are all web-based and don't require special software to be installed.
Bring your laptop along and we will walk through some examples together.
This workshop is facilitated by Dr Elke Pahl and Tristan O'Hanlon from the University of Auckland. Dr Pahl has created a number of Programming in Python (PiP) labs used in first year Physics and Tristan has implemented programming skills sessions in the training of beginning science and physics teachers.

High-rate reactive deposition of TiO_2 films for microstructured optical applications

Olejnicek J[1], Smid J[1], Cada M[1], Hubicka Z[1]
[1]Institute of Physics of the Czech Academy of Sciences, Prague, Czech Republic

Biography:
Jiri Olejnicek was born in the Czech Republic. He received his Ph.D. in physics in 2006 at Charles University in Prague. After that he worked until 2010 at the University of Nebraska in the United States. He is currently an employee of the Institute of Physics of the Czech Academy of Sciences, where he works as the head of the group of plasma deposition technologies. His research is focused on the preparation of thin films using magnetron sputtering and hollow cathode discharge.

TiO_2 is a very interesting material, especially with regard to its optoelectronic properties and chemical stability. Due to its extremely high refractive index in the visible range (n = 2.6), it is suitable for use in a wide range of optical applications. However, the plasma-chemical preparation of high-quality TiO_2 films is complicated and slow, especially due to the unwanted oxidation of titanium targets during the sputtering process. In this work, we present a plasma deposition technique that allows the reactive deposition of TiO_2 layers with an extremely high deposition rate. The new approach combines reactive sputtering by DC hollow cathode discharge with thermal evaporation from the hot surface of the hollow cathode. The uncooled titanium nozzle(s) served as hot hollow cathode(s) and simultaneously as an inert gas (Ar) inlet(s). The reactive gas (O_2) was introduced into the vacuum chamber through a separate inlet. During deposition, the temperature of the hollow cathode reached up to 1600 °C, depending on the discharge parameters. This made it possible to combine the ion sputtering of the metallic cathode with the thermal evaporation of its hot surface, which significantly increased the deposition rate of the final oxide material. The highest achieved deposition rate for TiO_2 was 567 nm/min (34 µm/h), which (with respect to the geometry of this process) corresponds to the total volume of the deposited TiO_2 material 1.2 mm^3/min per 1 kW of absorbed power. Despite extremely high thermal flux to the substrate, TiO_2 films were successfully deposited even on thermally-sensitive PET foil. Afterward, this technology was successfully used to prepare microstructured optical layers with a high refractive index on polymer substrates in order to develop new security elements for the protection of banknotes and documents.

Functional surface formation by ultrashort pulse laser processing

Ono S[1], Yu X[2], Tanaka Y[1], Cadatal Raduban M[3], Itoigawa F[1]
[1]Nagoya Institute of Technology, Gokiso-cho, Showa-ku, Nagoya, Aichi, Japan, [2]Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Aichi, Japan, [3]Massey University, Palmerston North, New Zealand

Biography:
Shingo ONO is an associate professor at Nagoya Institute of Technology. His work focuses specifically on the development of the ultraviolet sensor, optical components, laser measurement method, and laser processing technology.

Femtosecond to picosecond ultrashort pulse lasers are used for high-precision microfabrication because they can suppress the generation of the heat-affected zone. In recent years, the repetition rate of ultrashort pulse lasers has increased dramatically, and the average output power has achieved kilowatts level. This revolution of laser average power makes ultrashort pulse lasers more useful with increased processing efficiency. In this presentation, I will introduce our works about surface modification of semiconductors or metals substrates by using ultrashort pulse laser processing.
Terahertz (THz) waves (0.1 - 10 THz) has been studied for applications in a wide range of fields including 6G communication, imaging, and spectroscopy. Because the optical materials such as silicon in the THz region have high refractive indices, the refractive index mismatch at the interface results in a nonnegligible reflection loss. Consequently, reducing reflection loss is required for the improving the performance of THz systems. Subwavelength structures (also called moth-eye structures) consist of protuberances smaller than the wavelength of the incident waves. These moth-eye structures can enhance the zero-order diffraction and reduce the undesired high reflection loss. We utilized the advantages of ultrashort pulse laser processing to fabricate moth-eye structures consisting of micro tapers with various profiles and aspect ratios on high-resistivity silicon substrates. On the other hand, the typical materials (Si and GaAs) used in the THz region are too brittle, and applications of moth-eye structures are still limited by weak mechanical stability. To improve the mechanical stability and the antireflection characteristics, we designed a hybrid structure of moth-eye structures and coating to obliterate the refractive index mismatch smoothly. This hybrid structure is realized by employing ultrashort pulse laser processing and heat press coating. The simulated and measured results showed that the power reflectance was remained less than 6% in a super broad range from 0.6 THz to 2.5 THz. Such antireflection structures are expected to be expanded further application.
In addition, surface modification of metal leads to improved performance of machine parts such as automobiles, and can contribute to the realization of a sustainable society. We also introduce carbonization of Molybdenum (Mo) surface by ultrafast laser processing. Molybdenum carbides are being reported for various applications; for example, catalysts for sustainable energies, nonlinear materials for laser applications, protective coatings for improving tribological performance, and so on. We successfully fabricated molybdenum monocarbide (MoC) surface with laser-induced periodic surface structure (LIPSS) by using pulsed laser ablation of Mo substrate in hexane. The X-ray diffraction pattern of LIPSS surface indicates the formation of FCC MoC, agreeing with the results of electron diffraction. The results of X-ray photoelectron spectroscopy also showed the bonding energy attributed to Mo-C, and the sp2-sp3 transition was confirmed on the LIPSS surface. The results of Raman spectroscopy have also supported the formation of MoC and amorphous carbon structures. This simple synthesis method for MoC may provide new possibilities for preparing MoxC-based devices and nanostructures, which may contribute to the development of catalytic, photonic, and tribological fields.

Designing and implementing a novel major subject.

Parashar T[1], Perrott Y[1], Plank N[1], Ross A[1], Ruck B[1]
[1]Victoria University of Wellington, New Zealand

Biography:
Tulasi is a space physicist. www.wgtn.space

The space sector in Aotearoa is growing fast. The diversity of the space sector means that it is hard to predict which aspect of the space sector will grow to dominate. Currently it is the aerospace industry, in ten years' time it could be manufacturing of satellites, or operations, or something else. Our approach to this was to design a major that targets the broad overview of the space sector. We designed the learning plan such that a lot of subjects can be studied as a second major. We discuss the plan, design, and implementation of this major, a first in New Zealand, and potentially the first of its kind in the world.

Education for a career in space: ideas for discussion and debate

Pavri B[1]

[1]Paihau-Robinson Research Institute, lower hutt, New Zealand

Biography:

Senior Principal Engineer at Paihau-Robinson Research Institute

Recruiting a diversity of talented students and keeping them engaged and motivated is crucial to support Aotearoa's growing aerospace sector – both academia and industry. When preparing for a career in space science or technology, students often receive guidance to focus on science and maths classes. While this is good advice so far as it goes, several additional factors on how to improve student success & engagement are offered for discussion here.

Theoretical vs. Practical Learning: students often find it beneficial for classwork to be paired with laboratory/field work, as some students thrive more in the more theoretical environment of classroom, others more with practical applications (and understanding the applications helps with motivation).

Required skill set: Expertise in the so-called "hard skills" areas is necessary - but not sufficient - for success. "Soft skills" are also crucial, and these skills are often overlooked in STEM education. Examples include expertise in both technical writing and presentations, teamwork and collaboration, awareness of unconscious bias and how it can affect research formulation and analysis, and familiarity with social media & more traditional forms of public outreach.

Engaging with/recruiting support from the broader community: Encouraging colleagues in humanities classes, clubs, and other outlets to incorporate STEM-adjacent topics into their curricula will attract a wider spectrum of student participation. Straightforward examples include classes in history of science, science writing for lay audiences, or creative visualizations of scientific data. More creative examples might include recruiting geologists or biologists to lead regular hikes for a tramping club. Another interesting way to engage students is via storytelling/seminars – for example, hearing about and discussing famous engineering failures and debating the technical and cultural/ethical factors led to them.

Silicon-Germanium and Germanium Ring Resonators on-Chip with High Quality-Factors at Mid-Infrared Wavelengths

Perestjuk M[1,2], Armand R[2], Della Torre A[2], Sinobad M[3], Hartmann J[6], Fedeli J[6], Reboud V[6], Brianceau P[6], De Rossi A[7], Combrié S[7], Monat C[2], Grillet C[2], Boes A[1,4,5], Mitchell A[1]
[1]RMIT University, Melbourne, Australia, [2]Institut des Nanotechnologies de Lyon, 69131 Ecully, France, [3]Deutsches Elektronen-Synchrotron, 22607 Hamburg, Germany, [4]The University of Adelaide, Institute for Photonics and Advanced Sensing, Adelaide, Australia, [5]The University of Adelaide, School of Electrical and Mechanical Engineering, Adelaide, Australia, [6]CEA-Leti, 38054 Grenoble, France, [7]Thales Research and Technology,, 91767 Palaiseau, France

Biography:
Marko Perestjuk received the B.Sc. and M.Sc. degree in physics from Humboldt University Berlin, Germany, in 2018 and 2021. He is currently working toward the Ph.D. degree in engineering with the Institut des Nanotechnologies de Lyon, France, and RMIT University, Australia. His research interests include integrated photonics, mid-infrared photonics, nonlinear optics and integrated cavities.

The mid-infrared wavelength range (MIR, 3-13 µm) has a large potential for sensing applications, as many molecules have strong fundamental absorption lines in this range. However, the high-cost and bulky MIR technology has prevented a real breakthrough so far. The development of MIR photonic integrated circuits in group IV material platforms can provide a crucial step towards large scale applications. Silicon-germanium and germanium are attractive material platforms due to their transparency in the mid-infrared, CMOS-compatibility and suitability for nonlinear applications. Ring resonators are especially expected to play an important role due to their ability to effectively confine light. This is crucial for utilizing material nonlinearities for e.g. frequency comb generation, or increasing light-molecule interactions for sensing applications.
We will present experimental results of ring resonators with high quality-factors at mid-infrared wavelengths, fabricated on SiGe-on-Si and Ge-on-Si chip-based platforms. The rings exhibit loaded Q-factors of more than 200,000 at the operating wavelength of 4.2 µm. We determine that the waveguide propagation losses and bending losses together are as low as 0.2 dB/cm indicating that the Q-factor can be increased even further. Furthermore, we have dispersion engineered the waveguides to be suitable for nonlinear applications and our simulations show that this platform can be suitable for Kerr frequency comb generation in the mid infrared. We will present our most recent results in this direction at the conference along with our outlook for the remaining challenges to achieve broadband mid-infrared on-chip optical frequency combs that can be used for real world sensing applications.

Deposition of WO_3 and ZnO films by reactive magnetron sputtering

Pisarikova A[1,2], Hippler R[1,3], Wulff H[3], Olejnicek J[1], Nepomniashchaia N[1], Hubicka Z[1]
[1]Institute of Physics of The Czech Academy of Sciences, Prague, Czech republic, [2]Joint Laboratory of Optics Palacky University Olomouc, Olomouc, Czech republic, [3]Institut für Physik Universität Greifswald, Greifswald, Germany

Biography:
I am a PhD student of applied physics in Olomouc, Czech Republic. My research involves depositing various semiconductor layers onto different substrates using low-temperature plasma.

This contribution presents the plasma deposition techniques, namely r-RF sputtering, r-HiPIMS (+ECWR), and r-MF (+ECWR), that were used to prepare WO_3 and ZnO films. WO_3 is a wide-band gap semiconductor with excellent electrochromic and photochromic properties, and it has been extensively studied for its gas sensing, catalytic applications, and as catalysts in photoelectrochemical (PEC) processes for solar fuel generation. ZnO has also been widely studied for its gas sensing, biosensing, and environmental sensing applications, demonstrating high sensitivity, selectivity, and response time to various target analytes, such as gases.
Tungsten oxide films were deposited using reactive magnetron sputtering with an argon/oxygen gas mixture. A circular magnetron sputtering source equipped with tungsten target was used to deposit WO_3 films onto various substrates, including soda-lime and FTO glass, silicon, and quartz. The deposited films were annealed in air after deposition. ZnO films were also deposited using reactive magnetron sputtering methods on various substrates with an argon/oxygen gas mixture. The layers were then annealed and characterized.
Annealing process was applied to improve the crystallinity and semiconductor properties on the thin films. Films obtained from different reactive magnetron discharge modes were analysed and compared using X-ray diffraction (XRD), Raman spectroscopy, ellipsometry, SEM and photoelectrochemistry. Specifically, photoelectrochemistry measurements were performed on WO_3 and ZnO samples deposited on FTO glass.

Carbon Nanotube Field Effect Transistor Platforms for Sensitive and Real-time Sensing

Cassie1 E[1, 2], Happe E, Nguyen H[1, 2], Plank N[1, 2], Treacher E[1, 2]
[1]School of Chemical and Physical Sciences, Victoria University of Wellington, Wellington 6021, New Zealand, [2]The MacDiarmid Institute for Advanced Materials and Nanotechnology, Wellington 6021, New Zealand

Biography:

Dr Natalie Plank is a Senior Lecturer in Physics in the School of Chemical and Physical Sciences at Victoria University of Wellington (http://www.victoria.ac.nz/scps/about/staff/natalie-plank). She is also a Principal Investigator of the MacDiarmid Institute (http://macdiarmid.ac.nz/our-people/principal-investigators/dr-natalie-plank). Since being at VUW since 2009, Natalie has established the cleanroom fabrication facility < https://www.wgtn.ac.nz/scps/research/facilities/cleanroom> and runs the Nanomaterials Devices Group < https://www.wgtn.ac.nz/scps/research/research-groups/nanomaterials-devices-group>, where she and her team work on nanomaterial biosensors and nanowire electronics. She also enjoys teaching, covering some electromagnetism, quantum mechanics and solid state physics.

Functionalised carbon nanotube and graphene field effect transistors (CNTFETs and GFETs) have been used as the active channel in biosensors, with the future promise of lab-on-a-chip diagnostics strongly motivating the research [1]. The ability to effectively sense analytes depends on multiple factors, the conductivity of the platform [2], the robustness of the functionalisation and the selectivity and function of the receptor [3].
Here I will present our recent work on the development of the CNTFET and GFET platforms with aptamers and insect odorant receptors and the different challenges and device constraints we have encountered. I will discuss how the sensitivity of the CNTFETs can be optimised via the device platform. I will also discuss how functionalisation affects the device performance and the challenges in maintaining robust functionalisation protocols when using complex device fabrication routes. I will also outline the potential for biosensors in real-world applications.

[1]. T An et al, Lab Chip, 2010,10,2052-2056
[2]. M Thanihaichelvan et a., Biosensors and Bioelectronics, 2019, 130, 408-413
[3]. Nguyen et al., Nanomaterials, 2021 11 (9), 2280

Tunable cross-luminescence in wide bandgap fluoride crystals through high pressure application

Raduban M[1,2], Yamashita M[2,3], Mui L[2,3], Shibazaki Y[4], Sarukura N[2], Yamanoi K[2]
[1]School of Natural Sciences, Massey University, Albany, New Zealand, [2]Institute of Laser Engineering, Osaka University, 2-6 Yamadaoka, Suita, Japan, [3]Graduate School of Engineering, Osaka University, 2-1 Yamadaoka, Suita, Japan, [4]Photon Factory, Institute of Materials Structure Science, High Energy Accelerator Research Organization, 1-1 Oho, Tsukuba, Japan

Biography:
Dr. Marilou Cadatal-Raduban is a Senior Lecturer at Massey University's School of Natural Sciences in Auckland, New Zealand. She is also a Specially Appointed Associate Professor at Osaka University Institute of Laser Engineering in Japan. Dr. Cadatal-Raduban obtained her PhD degree in Physics from the Graduate University for Advanced Studies in Japan. Her research interests include modelling of material properties using density functional theory; numerical and experimental characterization of solid-state sensors and scintillators based on crystals, glasses, and thin films; effects of ionizing radiation on material properties; development of semiconductor and wide band gap photodetectors; and spectroscopy of optical materials.

Scintillators are widely used for radiation detection in various industries. Scintillators used in applications involving time-of-flight measurements need to have a fast decay time and a high photon yield. Scintillation decay time becomes faster when the emission wavelength of the scintillator becomes shorter. Therefore, scintillators emitting in the vacuum ultraviolet region (VUV, wavelength = 100 nm to 200 nm) using wide band gap materials doped with rare earth activator ions are being investigated to develop fast-response scintillators. However, there is a tradeoff between decay time and light yield such that fast scintillators suffer from a low light yield. In addition, the VUV emission wavelength imposes limitations to the detector unit that can be used to collect the scintillation light. The ability to shift the luminescence to a longer wavelength, for example in the ultraviolet region, will enable easier detection of the fast emission. We report on the potential of the potassium magnesium fluoride (KMgF) and barium fluoride (BaF) crystals as fast-response scintillators with tunable cross-luminescence (CL) emission wavelength through high-pressure applications. By performing first-principles density functional theory calculations using the Perdew–Burke–Ernzerhof (PBE) hybrid functional including exact exchange (PBE0) and Green's function and screened Coulomb interaction approximation as implemented in the Vienna Ab initio Simulation Package using plane-wave basis sets within the projector-augmented wave method, we identify the specific valence-to-core band transition that results in the experimentally observed CL emission at 148 nm (8.38 eV) and 170 nm (7.29 eV) wavelengths with intrinsically fast decay times of 290 ps and 210 ps, respectively. Uniform volume compression through hydrostatic high-pressure applications could decrease the energy gap between the valence and core bands, potentially shifting the CL emission wavelength to the ultraviolet (UV) region from 200 nm (6.2 eV) to 300 nm (4.1 eV). The ability to tune and shift the CL emission to UV wavelengths allows for the detection of the CL emission using UV-sensitive photodetectors in ambient atmosphere instead of highly specialized vacuum UV detectors operating in vacuum while maintaining the intrinsically fast CL decay times, thereby opening up new possibilities for KMgF and BaF as fast-response scintillators.

Space Science and Aerospace Engineering Education at The University of Auckland

Rattenbury N[1], Cater J[2], Hefkey J[1]
[1]The University of Auckland, Auckland, New Zealand, [2]The University of Canterbury, Christchurch, New Zealand

Biography:
Dr Nicholas Rattenbury is a member of the Japan-NZ-US group the Microlensing Observations in Astrophysics (MOA) collaboration, the NZ COSPAR committee, the Strategic Leadership group for Te Pūnaha Ātea Space Institute, the Executive team for the Te Ao Mārama Centre for Fundamental Inquiry, the Chair of the NZ National Organising Committee for the International Astronomical Union and a former President of the Royal Astronomical Society of New Zealand. He is a Senior Lecturer in Physics at The University of Auckland.

The Auckland Programme for Space Systems(APSS) is a cross-institution enrichment programme for undergraduates at The University of Auckland. Students compete to design a CubeSat mission that will service a New Zealand societal need. The first satellite created by the APSS programme was APSS-I/Quaketec and was New Zealand's first satellite built by undergraduates with a scientific payload and delivered to orbit. It was launched on a Rocket Lab Electron on 20th November, 2022 (Return To Sender). I will summarise the APSS, the APSS-I/Quaketec mission and outline the future of the APSS. I will also describe the Masters in Aerospace Engineering and Bachelor of Advanced Science (Applied Physics: Space Systems) degrees available at The University of Auckland.

Using Magnetic data to understand electronic structure of rare-earth ions in crystals and nanoparticles

Reid M[1], Martin J[1], Wells J[1]
[1]University of Canterbury, Christchurch, New Zealand

Biography:
Mike is a graduate of University of Canterbury. After working in the USA and Hong Kong for several years he returned to New Zealand in 1993. His research. Most of his work is on spectroscopic properties of materials doped with rare-earth ions and the current focus is on understanding materials that have potential for quantum-information applications, and on nanoparticles for biomedical imaging, in collaboration with Jon-Paul Wells.

Photonic applications of rare-earth doped materials require accurate modelling of electronic states. Many potential materials for quantum-information applications have low-symmetry sites, where measurements of electronic energy levels alone do not give enough information to obtain crystal-field fits. However, we have shown that measurements of magnetic splitting along several magnetic field directions provides the necessary information to obtain unique solutions.
Nanocrystals doped with rare-earth (lanthanide) ions also have considerable potential for photonic technologies, from quantum computing to biomedical applications, including imaging, nano-thermometry, and photodynamic therapy. There has been recent interest in using magnetic fields to modulate energy transfer between lanthanide ions in nanocrystals to enhance these applications . Making good use of magnetic field effects requires a better understanding of the magnetic splitting of rare-earth ions in nanocrystals. Though the particles are randomly oriented, we have recently shown that useful information may be obtained by Zeeman spectroscopy of rare-earth-doped nanoparticles [1] and this data provides a more accurate analysis of the electronic structure of the rare-earth ions in the nanoparticles than zero-field data.
In this paper, we will discuss how magnetic splitting measurements can be used to provide the geometrical information essential to accurate crystal-field modelling in both bulk crystals and nanocrystals. We will discuss some outstanding issues and the potential for future improvements.

[1] J. L. B. Martin, J.-P.R Wells, M.F. Reid, 15, 100181 Opt Mater. X. (2022).

The Visible Spectrum of our Students

Rutherfurd T[1]
[1]Albany Senior High School, Auckland, New Zealand

Biography:
A transwoman, an autist, an engineer and a teacher, Thalia Rutherfurd has been teaching physics since the Covid year of 2020. She has a strong passion for ensuring all students (regardless of race, creed, gender, ability, etc) are able to engage in and build passion for physics and is currently pursuing a Masters in Education focusing in on experiences of our diverse students.

For any manner of reasons, we find ourselves with a more and more diverse range of students. Where once we only really thought about the different ethnic backgrounds of our students (if even that) we now live in a world (and therefore education system) with all manner of students, be they neurodiverse, LGBTQIA+, from mixed ethnic backgrounds, suffering maths anxiety, and all manner of other diversities. In order to best serve these students, they must see themselves in our subject. How then might one see themselves in physics? Physics is the world around use and how it works, it's mathematical models that explains the very laws of reality, so shouldn't everyone see themselves in that? While that would be ideal, this workshop will look at examples and methods for explicitly showing the diversity in those who have had significant impacts on physics, how students can see themselves in physics principles and concepts and will generally allow for discussion about such matters.
Some examples of diverse physicists include Sally Ride, the first female astronaut and LGBTQIA+, Einstein's possible dyslexia, Doctor Stephon Alexander, a physicist of colour who worked to extend the bounds of general relativity. Examples of principles students could see themselves in include, but are not limited to, the spectrum of light and how might they define themselves within that, the use of mechanics to decrease severity of disabilities, consideration of the brain as an electric system and how changing that could change where there is most energy in that circuit.

Collective emission of photons by an ensemble of atoms (time delayed feedback on cold atoms)

Sadeghi M[1], Parkins S[1,2], Hoogerland M[1,2]
[1]University of Auckland and Dadd-Walls center, Auckland CBD, New Zealand
[2]The Dodd-Walls Centre for Photonic and Quantum Technologies, New Zealand

Biography:
I am a PhD student at The University of Auckland- Physics department- in the cold atom experimental group.

The collective excitation and decay of atoms coupled to an optical waveguide form the basis for quantum optical effects [1-6]. However, when moving beyond weak excitation, both experimental and theoretical investigations become considerably more challenging [7]. In this work, we present our experimental findings on the long-delayed feedback for cold atoms.
Figure 1 illustrates the main portion of our experimental setup. A small fraction of the magneto-optical trap (MOT) laser beam passes through a double-pass acousto-optic modulator (AOM) configuration, which generates a strong probe beam with the desired frequency and amplitude. The Cs atoms are excited using this pump beam, which is oriented perpendicular to the nanofiber and arranged in a standing wave configuration to minimize the photon kick experienced by the atoms (Fig. 1). The pump beam also exhibits linear polarization perpendicular to the nanofiber axis [8]. In our measurements, we set the pulse duration to 30 ns, and during each experimental sequence, we initiate 1000 pulses (repetition rate: 0.5 MHz) and record the emitted photon counts into the fiber and their arrival times using a single-photon counting module (SPCM). Additionally, we histogram the arrival times of the photons. The fiber Bragg grating (FBG) mirror is included to provide time-delayed quantum feedback for the atoms. We present our findings in the context of an FBG mirror with very high reflectance.

References
[1] Ruddell, S. K., et al. "Collective strong coupling of cold atoms to an all-fiber ring cavity." Optica 4.5 (2017): 576-579.
[2] Lodahl, Peter, et al. "Chiral quantum optics." Nature 541.7638 (2017): 473-480.
[3] Mitsch, R., et al. "Quantum state-controlled directional spontaneous emission of photons into a nanophotonic waveguide." Nature communications 5.1 (2014): 1-5.
[4] Pennetta, Riccardo, et al. "Collective radiative dynamics of an ensemble of cold atoms coupled to an optical waveguide." Physical Review Letters 128.7 (2022): 073601.
[5] Hannes Pichler, Soonwon Choi, Peter Zoller, and Mikhail D. Lukin. Universal photonic quantum computation via time-delayed feedback. Proceedings of the National Academy of Sciences, 114(43):11362–11367, (2017).
[6] Solano, Pablo, et al. "Super-radiance reveals infinite-range dipole interactions through a nanofiber." Nature communications 8.1 (2017): 1-7.
[7] Liedl, Christian, et al. "Collective excitation and decay of waveguide-coupled atoms: from timed Dicke states to inverted ensembles." arXiv preprint arXiv:2204.04106 (2022).
[8] K. P. Nayak, P. N. Melentiev, M. Morinaga, F. L. Kien, V. I. Balykin, and K. Hakuta, "Optical nanofiber as an efficient tool for manipulating and probing atomic fluorescence," Opt. Express 15, 5431–5438 (2007).

Optical functionalities of ferroelectric oxide thin films

Sando D[1,2]
[1]University Of Canterbury, Christchurch, New Zealand, [2]UNSW Sydney, Sydney, Australia

Biography:
Daniel Sando earned his PhD in physics from the Queensland University of Technology in 2010. Following his PhD, he held postdoctoral positions at Unité Mixte de Physique CNRS/Thales (France) and the Center for Correlated Electron Systems (Seoul, South Korea) until 2015. He then joined UNSW Sydney as a research fellow. Since 2023 he has been a Senior Lecturer at the University of Canterbury. His research interests include multiferroics, complex oxide epitaxy, advanced X-ray and neutron diffraction characterization, and multifunctional properties of thin film and topological materials.

The electric-field-dependent optical response of ferroelectrics makes them important elements in optical devices such as modulators and beam deflectors [1]. In the inexorable drive to miniaturization, the appeal of integrated thin film optical devices has led to the incorporation of ferroelectric thin films on single-crystal substrates. These structures have attractive electro-optic modulation characteristics, interesting strain-dependent bandgap and refractive index, as well as promising possibilities for solar energy harvesting [1].
A recent addition to the arsenal of thin film ferroelectrics useful for optical applications is $BiFeO_3$ (BFO). It is multiferroic at room temperature with strong ferroelectric polarization and G-type antiferromagnetic ordering with a cycloidal modulation of the Fe spins [2]. While most research on this material has been driven by the prospect of electrically controlled spintronic devices [3], more recently, BFO has revealed further remarkable multifunctional properties. These include a strain-driven morphotropic phase boundary between the so-called T-like and R-like phases and a specific magnonic response that can be tuned by epitaxial strain or electric field. Moreover, with a bandgap (~2.7 eV) in the visible range, large birefringence (0.25–0.3), and strong photovoltaic effect, BFO is garnering interest in photonics and plasmonics.
These optical properties of BFO, particularly in thin films [2], are the topic of this contribution. We first reveal that the electro-optic effect (used for optical modulation) is sizeable in this material [4]. Next, we show by ellipsometry measurements on strain-engineered films that BFO possesses a large elasto-optic effect, that is, change in refractive index with applied strain [5]. We then demonstrate, using electric-field interconversion of T-like BFO and R-like BFO, that mixed-phase films can show electrochromism – a change in optical absorption with applied electric field. Finally, analysis of more than 40 epitaxial films shows that the optical band gap in BFO is insensitive to a wide host of physical parameters [6], making this material robust to processing variations, which could be an asset for photonic devices based on BFO.

References
[1] D. Sando et al., Appl. Phys. Rev. 5, 041108 (2018).
[2] J. Wu et al., Prog. Mater. Sci. 84, 335 (2016).
[3] H. Béa et al., J. Phys.: Condens. Matter 20, 434221 (2008).
[4] D. Sando et al., Phys. Rev. B 89, 195106 (2014).
[5] D. Sando et al., Nat. Commun. 7, 10718 (2016).
[6] D. Sando et al., Adv. Opt. Mater. 6, 1700836 (2018).

The Einstein-First Project – Training teachers to deliver a modern, activity-based science curriculum

Santoso J[1], Kaur J[1], Blair D[1]
[1]University of Western Australia, Perth, Australia

Biography:
Jesse Santoso is a physicist with a background in both experimental and theoretical plasma physics. His research has explored themes of nuclear fusion, renewable technologies, and green chemistry. He has significant experience teaching physics at a university level in both in-person and online formats. His primary activities include developing online teacher-training resources, producing teacher-training demonstration videos, and overseeing the Einstein-First Project's 'Einsteinian Science for School Teachers' micro-credential courses.

The Einstein-First Project is an initiative aimed at modernising the physics curriculum taught in primary and secondary schools in Australia and around the world. The project aims to teach all students the fundamental concepts of modern physics that underpin almost all the modern technologies that they interact with in their daily lives. The project has developed innovative hands-on activity- and play-based methods for teaching Einsteinian physics to school children to create an evidence-based modern curriculum for Years 3 to 10 (with Year 10 being the last year of compulsory science in Australia). This curriculum covers important and exciting topics such as spacetime, gravity, photons, quantum mechanics, renewable technology, and climate science in an accessible and engaging way that doesn't shy away from teaching students the "real science". The project seeks to address declining STEM participation rates and negative attitudes to science that have been compounded by the outdated 19th-century language of reality that is still taught in schools. We have achieved highly encouraging results with trials involving many hundreds of students across Western Australia. In these trials students have demonstrated high rates of comprehension and improved attitudes towards science. We will also have just launched the program at a national level in Australia in June. We are excited to explore opportunities to collaborate with our fellow educators in Aotearoa New Zealand and open the program for participation beyond Australia.

In this talk, we will be providing an overview of the Einstein-First curriculum and discussing the challenges associated with training, equipping, and supporting teachers to introduce a heavily activity-focused program across such a geographically spread out region as Australia and New Zealand. We will outline our approach to utilising an online web platform for lesson plans; accessible equipment made from simple everyday materials; and online teacher training in the form of micro-credential courses focusing on at-home activities and interactive online workshops.

We will also introduce our exciting new Quantum Girls initiative which aims to introduce all secondary school students to quantum science as part of the curriculum and provide hands-on access to quantum computing in extracurricular STEM clubs, while promoting and supporting the involvement of both female teachers and female students in STEM.

Discussion on talent support and on competitions

Schumayer D[1], O'Hanlon T[2], Brand J[3]
[1]Department of Physics, University of Otago, Dunedin, New Zealand, [2]Faculty of Science, Physics, New Zealand, Auckland, New Zealand, [3]Massey University, New Zealand Institute for Advanced Study, Auckland/Albany, New Zealand

Biography:
Dr Schumayer's background is in theoretical and mathematical physics. He has earned his doctorate in Physics from the Budapest University of Technology, Hungary, in 2004, then joined to the University of Otago as a Postdoctoral Fellow and later became a Lecturer. Previously he has been the Honorary Secretary of the New Zealand Society of Physics. In 2018 the American Physical Society has awarded him with an Outstanding Referee title. From 2019 he is one of the Associate Editors of the Journal of Royal Society of New Zealand.

University departments and research institutions often run outreach activities. Most of the time, researchers and educators visit secondary schools and dependent on the level of the visited class they may demonstrate some concepts which the class had already covered or they attempt to raise the students' curiosities by showing surprising experiments, demonstrations. These visits cater for a wide range of students, however, such visits are quite sporadic and cannot maintain regular engagement, especially with the most talented students.
Together with Tristan O'Hanlon (Auckland) and Joachim Brand (Massey) I would like to hold an open discussion on two ideas:
1] how talented students could be best supported; and
2] would there be 'appetite' for a Physics Olympiad type competition?

One problem and four approaches

Schumayer D[1]
[1]Department Of Physics, University of Otago, Dunedin, New Zealand

Biography:
Dr Schumayer's background is in theoretical and mathematical physics. He has earned his doctorate in Physics from the Budapest University of Technology, Hungary, in 2004, then joined to the University of Otago as a Postdoctoral Fellow and later became a Lecturer. Previously he has been the Honorary Secretary of the New Zealand Society of Physics. In 2018 the American Physical Society has awarded him with an Outstanding Referee title. From 2019 he is one of the Associate Editors of the Journal of Royal Society of New Zealand.

Kinematics is a central part of the NCEA curriculum, within which the superposition principle is also often taught and analysed. A typical problem in this context is that of the two-dimensional projectile motion. I am going to discuss a version of this problem using different approaches. These approaches vary in their elegance; one will be a 'lumberjack' solution which applies the basic principles directly and just goes ahead with brute force until the answer is found, while other approaches will be unconventional and certainly interesting. Each approaches should be suitable for some types of students, assuming solid understanding of the physics and mathematics concepts taught in secondary schools.

Passive optical sensing: defects, dopants, and luminescence in wide bandgap optical materials

Schuyt J[1], Nalumaga H, Williams G[2], Chong S[1]
[1]Paihau—Robinson Research Institute, Victoria University of Wellington, Wellington, New Zealand,
[2]School of Chemical and Physical Sciences, Victoria University of Wellington, Wellington, New Zealand

Biography:

Dr. Joe Schuyt researches luminescent materials and optics, with an emphasis on the development of real-world devices. His research spans topics in materials science, applied physics, and engineering. Currently, his research is focused on developing new luminescent materials for applications in long-term optical data storage, and optical methods of sensing in harsh environments.

Conventional electronic sensors have proven incredibly useful over the last 100 years, finding applications across practically all industries. However, there are many environments in which electronic sensing presents numerous challenges. The harsh radiation environments of fusion reactors, the hazardous electric fields encountered in power generation and distribution systems, and the isolated, low-energy nature of space are just a few examples of environments that will benefit from the advent of new sensing technologies. To that end, optical sensors are a promising way forward. Optical sensors can be made immune to electromagnetic interference, made to consume very small amounts of energy, and made resistant or sensitive to radiation, as required – thus, optical sensors are the ideal choice of sensor for many extreme environments.
Here, we will focus on the increasing use of defects, dopants, and luminescence as physical means of sensing physical phenomena (e.g., radiation dose, time, temperature), as well as the challenges involved in implementing such sensors. Attention will be given to the concept of passive sensing, whereby sensing is performed by materials intrinsically – in the absence of any external motivation (e.g., electricity or light). Passive sensing is achieved via various charge transfer processes and by making use of metastable defect (or dopant) states in wide bandgap compounds, e.g., fluorides and oxides. We will discuss the physics of such materials, and examples related to applications including radiation dosimetry, time and temperature sensing, and sensing in radiation-rich environments. We will also discuss parallel ‘sensing’ applications, such as optical data storage.

Measuring the Attitudes and Wellbeing of First Year Health Science Students: Effect on Academic Performance

Scott T[1]
[1]University Of Otago, Dunedin, New Zealand

Biography:
Dr Scott has been a Senior Teaching Fellow in the Department of Physics at the University of Otago since 2003. He has taught courses at all levels in the physics curriculum and is active in physics education research. He is the current course coordinator for PHSI191, a large first year physics service course.

In this talk I will describe a collaboration between the Department of Physics and the Department of Psychology at the University of Otago. In this collaboration we are
investigating the dynamics of a number of psychological factors in our large first year physics service course, PHSI191 Biological Physics. We are looking at the levels and distribution of psychological factors such as feelings of belonging, wellbeing, resilience and efficacy, and how these factors are correlated with performance in the course. We are also investigating the effect of a "values affirmation intervention" on these factors and on academic performance.
Previous research has shown that a values affirmation writing exercise improves the academic performance and course retention of undergraduate students. This research also indicates that this sort of intervention is especially effective in promoting positive outcomes amongst students traditionally under-represented in Physics (e.g., women, Māori/Pasifika, First Generation at Uni, low socio-economic status, etc). I will briefly summarize some of this previous research and outline some of the suggested mechanisms by which such an intervention may work.
I will then describe the study which is currently underway at the University of Otago.

Potential pathways for Aotearoa space sector

Searle T[1]
[1]New Zealand Space Agency

Biography:
Tim is a Principal Policy Advisor at NZSA. He has an interest in space business models and the economics of space/space projects.

Tim has been invited to discuss how the space sector might grow in the next decade.

Interactive Quizzes for use in Physics Classrooms

Standley M[1]
[1]Whanganui Collegiate School, Whanganui, New Zealand

In this presentation I will cover a selection of interactive quizzes (free and subscription) to use with Senior Physics students:

- Kahoot
- Blooket
- Wordwall
- Quizizz
- Quizlet
- Isaac Physics (free)
- Who wants to be a Millionaire (Free Slide Chef template)
- And many many more...

Besides providing a way for you to check how your students are managing with the vocabulary, these quizzes are also a chance to do something fun!
With such an overwhelming number of choices, it is important that you start by deciding why you want to use live quizzes in the first place. What are the objectives and is it worth the effort?

2024 and Beyond – Assessment and teaching programmes

Thrasher D[1], Housden D
[1]St Cuthbert's College, Auckland, New Zealand, [2]St Bernard's College, Lower Hutt, New Zealand

Biography:
Dave Thrasher has been a physics teacher in NZ since the late 90s at various schools, helping out in various ways to ensure teachers can learn from each other & share resources. This includes managing the shared physics teacher drive, the physics realm site, organizing a yearly gathering of teachers in Auckland and helping out with NZIP in various other ways.
David Housden is a man that needs no verbose introduction. Among other things he is the president of NZIP education and involved in a plethora of activities & organizations to help the physics teachers and physics students of NZ.

This will be a workshop and discussion that explains the current state of NCEA and what may lay ahead in terms of assessment and teaching programmes.

Could Planck's constant have a relativistic classical origin?

Trompetter B[1]
[1]GNS Science, Lower Hutt, New Zealand

Biography:
Bill is a physicist at GNS Science in Lower Hutt. He has helped develop the Ion beam analysis (IBA) capabilities used at GNS to modify and analyse materials. He has and continues to investigate a variety of materials including geological materials, air particulates, coatings, and development of new materials. The new materials work at GNS is now focused on energy efficient modern applications for a low carbon future.

Quantum mechanics is a very successful theory that provides a description of physical properties for electromagnetic light and particles at the atomic scale or smaller. Energy levels or more specifically angular momenta are quantised in units of Planck's constant $L=n\hbar$. Planck's constant has been determined experimentally, and the reason why quantisation occurs has been elusively unknown. Here, the relativistic effects of rotating electromagnetic fields are explored in both the rotating frame of reference and the lab frame of reference. In the lab frame of reference, electric fields are radial and straight, whereas in the rotating frame of reference electric fields take on circular trajectories with a maximum radius of $R = c/\omega$. The surprising result is that for the total energy to be invariant across these frames of reference and avoid violation of special relativity, angular momentum is required to have a specific value. The calculated specific value ($L = ke^2/c$ 136.96 = 1.05399×10-34 J.s) is in close agreement (99.94%) with the experimentally determined value for the reduced Planck constant ($\hbar$).
Hence these surprising results suggest that Planck's constant is a natural extension of classical electromagnetism and conservation of energy in a rotating frame.

Plasma mediated water splitting

Trompetter B[1], Cooke M[1], Futter J[1], Kennedy J[1]
[1]GNS Science, Lower Hutt, New Zealand

Biography:
Bill is a physicist with the Material's Team at GNS Science in Lower Hutt. He has helped develop the Ion beam analysis (IBA) capabilities used at GNS to modify and analyse materials. He has and continues to investigate a variety of materials including geological materials, air particulates, coatings, and development of new materials. The new materials work at GNS is now focused on energy efficient modern applications for a low carbon future.

Plasmas are widely used to convert a variety of feedstock molecules into other new species. Using a non-thermal plasma offers the potential avenue to overcome both the kinetic and thermodynamic limitations of other chemical transformation methods [Bogaerts 2020]. Hence a plasma system has the potential to split water with high throughput and efficiency to produce green hydrogen. Furthermore, a plasma has the potential to use wastewater and purify the water. While some lab-based studies have established the feasibility of such plasma processes, this approach has not received much attention despite the current interest in green hydrogen production. This presentation will outline our initial investigations and experiments on liquid water, and outline our future research aims of using plasma either on its own or in conjunction with electrolysis or with catalysts to enhance H_2 production.

Reference:
A. Bogaerts et al 2020, “The 2020 plasma catalysis roadmap”, J. Phys. D: Appl. Phys. 53 443001

Take advantage of APC-free publishing in New Zealand

Trotter I [1]
[1]IOP Publishing

The new CAUL transformative agreement with IOP Publishing provides APC-free open access to researchers in Australia and New Zealand. During this session we will be taking a closer look at the agreement, with the aim of helping you feel more confident in navigating your open access publishing options with IOP Publishing.

Public science engagement for physics student employability and engagement

Whittaker I[1]
[1]Nottingham Trent University, Nottingham, UK

Biography:
Dr Whittaker is a senior lecturer in physics and teaches modules on the Physics with Astrophysics degree stream for undergraduate study.
In 2019 Dr Whittaker won the Sir Paul Curran Award for Academic Communication from the The Conversation. His current public science profile also includes articles in national newspapers, BBC Frontiers magazine, and Physiology Today. His current readership in The Conversation is over 4 million and he is the most read author from NTU.
In 2021 Dr Whittaker won the Vice Chancellors Outstanding Teaching Award for an Early Career Teacher, and also the NTSU Teaching Award for Science and Technology.

The importance of communication to a range of audiences is a vital skill for physicists and starting this journey as early as possible with learners develops their critical thinking skills as well as making students able to perform excellently at job interviews.
In this talk I will cover one of my public engagement of science workshops for year 3 undergraduate students, covering the implicit bias in how science is presented in the media and how to use skills from celebrities, streamers, and science interviews to communciate their own science.
I will also be showing some anonymised exemplars of student work from these workshops to show how effective a short session can be, opening up the creativity of students who are used to formalised assessments and clear mark schemes.
This workshop has led to teaching awards, and is based off of my own extensive public science engagement with 'The Conversation' and international media appearances.

An interdisciplinary view of bee magnetosense

Whittaker I[1], Houlston T[2], Duncan E[3]
[1]Department of Physics - Nottingham Trent University, Nottingham, UK, [2]School of Biological Sciences - University of Aberdeen, Aberdeen, UK, [3]School of Biology - University of Leeds, Leeds, UK

Biography:
Dr Whittaker is a senior lecturer in physics and teaches modules directly related to Physics with Astrophysics degree stream for undergraduate study. He has held six postdoctoral research contracts around the UK and New Zealand with research spanning space physics, meteorology, and medical physics. Dr Whittaker's main research interest lies in the connection between the Sun and the Earth. He is also a member of the SMILE mission team, a joint European and Chinese satellite mission to observe X-ray charge exchange emission at the magnetopause boundary.

The idea of magnetic fields affecting an organisms ability to orient itself is a relatively new one, with research being published from a range of academic fields including biology, zoology, chemistry, botany, and physics. We present a review of the most cited publications covering honeybees and bumblebees, providing a critical analysis of them from a multidisciplinary viewpoint. We also highlight where the experiments are non-viable or have unreasonable methodology or conclusions and include an example we have trialled ourselves.
The most common issue with the current research is a lack of knowledge of the Earth's magnetic field and variation. We provide examples of which results can be trusted and examples of what experiments need to be carried out to advance the field.
The importance for future studies that multidisciplinary research teams are involved is discussed. Some commonly held issues with these studies, such as using sunspot number as a proxy for background magnetic field monitoring is covered. This talk aims to encourage physics researchers to collaborate more strongly with other scientific fields to ensure rigorous results, as well as encourage collaboration with our research.

Structural and Magnetic studies of CoMoO4

Williamson J[1,2], Chong S[1], Schuyt J[1], Bioletti G[1], Banks S, Williams G[2]
[1]Victoria University Wellington, Wellington, New Zealand, [2]Robinson Research Institute, Victoria University of Wellington, Wellington, New Zealand

Biography:
Joey Williamson is currently pursuing a PhD at Victoria University Wellington in the School of Chemistry and Physical sciences. Prior to this in 2020 he successfully completed a BSc in Physics, and a MSc(Res) in Quantum Photonics, both at the University of Sheffield.

The AMoO4 transition-metal molybdates have received considerable investigation (A=divalent transition metal ion) because of their interesting structural and optical properties, leading to potential applications that range from catalysts to supercapacitors [1]. Some of these molybdates also exhibit piezochromic and thermochromic behaviour due to shifting absorption spectra between different phases [2]. CoMoO4 is one such compound, with a pressure-induced phase transition in the MPa-range and a clearly visible colour shift— from purple to green, making it particularly promising for applications based on this optical shift [3].
This report characterises CoMoO4 in powder and thin film form, focusing on structural and magnetic measurements. Thin film CoMO4 samples were made by RF sputtering and post annealing. Powder samples were formed using conventional solid-state synthesis method. Raman and X-ray spectroscopy were used to develop synthesis routes for both optically active phases (α-CoMoO4 and β-CoMoO4) in powder and thin film form. Magnetic measurements reveal antiferromagnetic behaviour below a Néel temperature around 10K for both powder and film. Both forms also show two distinct spin-flop transitions, notably at a lower critical field than those seen for the other molybdates.

Unusual Geometries Following Drop Impacts

Willmott G[1]
[1]University of Auckland, Auckland, New Zealand, [2]The MacDiarmid Institute for Advanced Materials and Nanotechnology,

Biography:
Geoff is an Associate Professor in Physics and Chemistry at the University of Auckland, and a Deputy Director at the MacDiarmid Institute.

This presentation will discuss situations in which the outcome of a vertical drop impact onto a flat solid surface is affected by the material properties of either the drop or the surface. When an array of micropillars is arranged on the surface, it can break the azimuthal symmetry of the spreading drop, producing eye-catching outcomes with eight-fold symmetry [1]. The geometry of the spreading is highly sensitive to a wide range of experimental parameters, including the size and velocity of the drop, and the precise design of the micropillar array. The evolution of the experimental outcome can be tracked and physically explained through various stages: from impact, to penetration of the microstructure, to jetting from underneath the drop, to nucleation of protrusions at the rim, and to merging and growth of those protrusions as the drop continues to spread. In another type of experiment, ferrofluids have been observed landing and spreading on a glass surface above a simple bar magnet. In this situation, the formation of the ferrofluid's characteristic equilibrium instabilities is affected by the dynamic spreading of the droplet. Regimes for peak and rim formation are identified and explained as a function of the strength of the non-uniform magnetic field, as well as the impact conditions. The ability to shape the outcomes of drop impacts has intriguing potential for future applications in areas such as advanced coatings and additive manufacturing.

[1] M. Broom and G. R. Willmott, "Water Drop Impacts on Regular Micropillar Arrays: The Impact Region", Phys. Fluids 34, 017115 (2022)
[2] A. Cordwell, A. Chapple, S. Chung, F. S. Wells, G. R. Willmott, "Ferrofluid drop impacts and Rosensweig peak formation in a non-uniform magnetic field", arXiv:2204.05523v1.

Training and Tracking the Alumni of the MacDiarmid Institute

Willmott G[2]
[1]University of Auckland, Auckland, New Zealand, [2]The MacDiarmid Institute for Advanced Materials and Nanotechnology

Biography:
Geoff is an Associate Professor in Physics and Chemistry at the University of Auckland. Since 2018 he has been a Deputy Director (Commercialization and Industry Engagement) at the MacDiarmid Institute.

New Zealand's Centres of Research Excellence (CoREs) are funded by the Tertiary Education Commission, and one of the primary goals of this scheme is to "build research capacity and capabilities through post-graduate programmes and the training of new researchers." One of the currently-funded CoREs, the MacDiarmid Institute for Advanced Materials and Nanotechnology, turned 20 years old last year. The Institute has ~40 Principal Investigators and ~150 affiliated students based predominantly in physics, chemistry and engineering research groups throughout New Zealand's universities.
This talk will focus on career directions of the MacDiarmid Institute's alumni. A recent informal survey of >400 of these alumni found (for example) that around two-thirds stay in New Zealand, >70% of those working in industry occupy a technical or science role, and one in eight found work in a start-up company. Seven had become CEOs or founders of their own companies, and nine have been nominated for KiwiNet Research Commercialization Awards. The Institute actively (and increasingly) encourages its students to build skill-sets that will be useful for their careers, whether in academia or elsewhere. In the last two years, the training it provides has been formalised within a Commercial and Relevant-to-Industry Skills Programme (CRISP [1]). Other initiatives include funding of internships within industry or government, and offering Alumni Business Scholarships [2] to enable further postgraduate study in business-related areas. Tracking the careers of graduates is one aspect of an effort to understand the Institute's broader impact on New Zealand, which will also be discussed.

[1] www.macdiarmid.ac.nz/what-we-do/into-the-future/career-and-relevant-to-industry-skills-programme-crisp/
[2] www.macdiarmid.ac.nz/about-us/join-us/business-scholarships/

Describing rechargeable batteries as fractional capacitors

Wilson M[1], Dunn C[2], Farrow V[2], Cree M[2], Scott J[2]
[1]Te Aka Mātuatua - School of Science, University of Waikato, Hamilton, New Zealand, [2]School of Engineering, University of Waikato, Hamilton, New Zealand

Biography:
Marcus Wilson is a senior lecturer in Te Aka Mātuatua - School of Science at The University of Waikato. He has a PhD in theoretical solid state physics, but currently has particular research interests in modelling the physics of the interactions of electromagnetic fields and the brain, and more recently the modelling of rechargeable batteries. He teaches across a wide range of physical science disciplines including climate change and science communication. He has previously served as treasurer of the NZIP.

Rechargeable batteries, particularly for power applications (e.g. vehicles), are a rapidly growing area of research as the world looks to transition away from fossil fuels. The electrical behaviour of batteries can be complicated – for example some batteries can exhibit strong memory effects. In the Battery Modelling Group at the University of Engineering, we have been using equivalent circuit models of batteries that include fractional capacitor elements. A fractional capacitor could be considered as something between a capacitor and a resistor. For example: a pure capacitor has an impedance that scales as 1/f where f is frequency, and a phase of -90°; a pure resistor has an impedance that does not scale with f and a phase of 0°; a fractional capacitor has an impedance that scales as 1/f to the power α and a phase of -90° × α where $0 < \alpha < 1$, for some fractional order α. The relationship between voltage and current for fractional capacitors is described mathematically through fractional calculus, using non-integer derivatives and integrals. A key implication is that battery behaviour is non-local in time – meaning voltage is not a simple function of the charge stored, but rather a functional of the history of the charge. For example, the amount of charge that can be extracted from a fractional capacitor depends on how quickly one extracts it. By measuring battery impedance across a wide frequency range (down to order μHz in frequency) and by measuring voltage responses to specified current inputs (e.g. square waves) we have been able to characterize a wide range of batteries in terms of their fractional orders and capacitances. We present some of the results and interpretations of these measurements, and implications for use of rechargeable batteries.

Everett's Many-Worlds Theory

Wu B[1]
[1]International Center for Quantum Materials, School of Physics, Peking University, Beijing, China, ,

Biography:
Biao Wu is a Professor of Physics at the International Center for Quantum Materials at Peking University. He received his B.S. in 1992 from Beijing Normal University, M.S. in 1995 from University of Chinese Academy of Sciences in China, and Ph.D. in Physics in 2001 from the University of Texas at Austin in USA. He was a postdoc associate at Oak Ridge National Laboratory, USA before joining the Institute of Physics of Chinese Academy of Sciences. He moved to the current position in 2010. He won the Daniel Tsui Fellowship of Hong Kong University in 2007. His current research focuses on quantum Hamiltonian algorithm and quantum dynamics.

The nature of quantum measurement has been controversial since the establishment of quantum mechanics in 1926. The mainstream Copenhagen interpretation states that during measurement, a quantum system's wave function collapses from a superposition of multiple states into a definite state. However, Hugh Everett challenged this view in his 1957 PhD thesis by proposing the many-worlds theory. I will use Schrödinger's cat thought experiment to illustrate the essence of the many-worlds theory and explain why it is superior to the Copenhagen interpretation. The Oscar-winning film Everything Everywhere All at Once is set within a multiverse. I will analyze how certain scenes accurately reflect the many-worlds theory while others were created for artistic effect.

Reference:
[1] B.S. DeWitt, N. Graham (eds.), The Many-Worlds Interpretation of Quantum Mechanics (Princeton University Press, Princeton, 1973)
[2] P. Byrne, The Many Worlds of Hugh Everett III (Oxford University Press, New York, 2010)
[3] Biao Wu, Eur. Phys. J. H 46 (2021) 7; arXiv:2005.04812 (2020).
[4] Biao Wu, Quantum Mechanics: A Concise Introduction (Springer, 2023).

Development of scintillators for inertial confinement fusion experiments

Yamanoi K[1]
[1]Osaka University, Yamadaoka 2-6, Suita, Japan

Biography:
2021 – Associate Professor, Osaka University, Japan
2013 – 2021 Assistant Professor, Osaka University, Japan
2012 – 2013 Postdoctoral Fellow of the Japan Society for the Promotion of Science, Osaka University, Japan
Present research/professional speciality:
Development of laser materials and scintillators (crystals, glasses, thin films), Development of fuel target Materials for inertial confinement fusion, Tritium science, Spectroscopy of optical materials

For decades, nuclear fusion has been studied in key research institutions all over the world. Understanding the dynamics of the imploded fusion-plasma is a key issue in inertial confinement fusion (ICF) experiments. Scattered-neutron diagnostics is one of the most desirable methods in studying the fuel aerial density of the imploded plasma. In this method, a sufficiently fast-response neutron scintillator is necessary for time-of-flight measurement. We report the optical properties of rare-earth (RE) -doped APLF [20Al(PO3)3-80LiF] glasses as fast-response scintillators. The optical properties were characterized using photoluminescence and photoluminescence excitation spectra of the Pr3+- and Ce3+-doped APLF glass samples for doping concentrations ranging from 0.1 to 3.0 mol%. The decay times of APLF80+Pr3+ were constant at different temperatures from 0K to 300K and became faster with increased doping concentration from 19 ns (0.5% Pr3+) to 16 ns (3.0% Pr3+). The decay times of APLF80+Ce3+ glasses were the same in the range from 38 to 41 ns regardless of Ce concentration. These results highlight that the scintillation decay times from both Pr3+- and Ce3+-doped APLF glasses are significantly faster than conventional glass scintillators and therefore these glass samples are more advantageous for fast-response scintillator applications.
References:
[1] Arikawa Y. et al., Opt. Mat. 32 2010 1393-1396.

Shapeshifters: Where physicists actually work

Yang A[1]
[1]The University of Auckland, Auckland, New Zealand

A physics degree has sometimes been referred to as the ‘Swiss Army Knife’ degree in the Sciences, given the wide applicability of the rich skill set acquired during the students’ academic training. While a few physicists build their entire careers in academia, the majority work outside academia for all or part of their careers. In this talk, we will draw from findings reported in the US, UK, Australia and New Zealand to survey common careers of physicists, identify qualities of physics graduates valued by employers, discuss implications of ‘emotional geography’ on physics graduate career outcomes, and provide provocations for physics students, educators, and employers to create a thriving future world and forge fulfilling careers.

Characterisation of Potential Energy Surfaces: Neon Clusters in Strong Magnetic Fields

Yu T[1], Smith N[2], Garden A[2], Pahl E[1]
[1]The MacDiarmid Institute for Advanced Materials and Nanotechnology, Department of Physics, University of Auckland
[2]The MacDiarmid Institute for Advanced Materials and Nanotechnology, Department of Chemistry, University of Otago

Biography:
Diana (Tiantian) Yu is a PhD student at the University of Auckland. Her research interests are in condensed matter physics, atomic physics, quantum chemistry and astrophysics. She is currently focusing on atomic systems under extreme conditions such as strong magnetic field and high pressure. She hold a Master of Science degree from the University of Auckland, and a Bachelor of Science degree from the University of Science and Technology of China.

Magnetic fields influence the properties of matters by interacting with atomic orbitals and spins. Strong magnetic fields in the order of 10^5 T can be found on magnetic white dwarfs, under such extreme conditions, a new binding mechanism called perpendicular paramagnetic bonding [1] is found for certain atomic systems, such as hydrogen and rare gases. This strengthens the bonds between atoms when they bond perpendicular to the magnetic field.
Neon clusters in a strong magnetic field are investigated using the basin-hopping algorithm [2], which is an effective method to explore potential energy surfaces to find stable structures, the local and global minima. New ground states are found adopting different symmetries to the field-free cases. The new minima share one similarity: they are flatter, with atoms arranged into semi-layers perpendicular to the direction of the magnetic field, which clearly shows the influences of the perpendicular paramagnetic bonding mechanism.
All minima are assigned individual structure profiles by an algorithm based on common neighbour analysis (CNA) [3], and they are further categorised according to their symmetries [4]. The CNA profiles and categories can be used to visualise funnels on the potential energy surface and transitions (hoppings) between them, also giving an indication of how difficult it is for a cluster to transition from one structure to another.
The nudged elastic band method [5] is also used to find the minimum energy path between two structures along the potential energy surface, the difficulties introduced by translational, rotational and exchange symmetries are discussed. The basic nudged elastic band method is found to work well for very small clusters in magnetic field, but needs improvement for larger clusters with a wider range of more complicated structures.

[1] K. K. Lange, E. I. Tellgren, M. R. Hoffmann, and T. Helgaker, Science, vol. 337, no. 6092, pp. 327–331, 2012.
[2] D. J. Wales and J. P. Doye, Journal of Physical Chemistry A, vol. 101, no. 28, pp. 5111–5116, 1997.
[3] G. R. Weal, Univeristy of Otago, 2021 [Unpublished doctoral thesis].
[4] D. Schebarchov, F. Baletto and D. J. Wales, Nanoscale, vol. 10, no. 4, pp. 2004-2016, 2018.
[5] G. Henkelman and H. Jónsson, Journal of Chemical Physics, vol. 113, no. 22, pp. 9978-9985, 2000.

Abstracts – Poster Presentations

Participating in the Koeberg Nuclear Power Reactor (under-construction) Debate, Cape Town, June 1979 to April 1980; an outline for young physicists.

Bartle M[1]
[1]Penguin Scientific and Medical Ltd, Wellington, New Zealand

Biography:
Penguin Scientific and Medical Ltd encourages young physicists to grasp opportunities that broaden their capability and thus improves NZ's prosperity; Murray's PSM activities: 2011-2015 a contracted lecturer in Applied Physics (experimental techniques and nuclear energy) at SCPS, VUW; 2010-2013 an IAEA Expert Asia/Pacific working with scientists in China, Malaysia and Vietnam. Murray's DSIR/GNS activities: 1986-2010 led/originated research on accurate fat measurement on meat processing conveyors at production speed; 1996-2009 IAEA International Co-operative Research (CRPs); 2003-2006 consultant to NZ Customs on security scanner performance; 2005-2013 a Principal Investigator in the Radiation Imaging Group led by Assoc. Prof. Andrew Edgar at VUW.

This poster outlines the author's experiences in the Koeberg Nuclear Reactor public debate, the University of Cape Town (UCT) Summer School Symposium 'Why Koeberg?' (January 1980) and the Science Student Council Symposium on Nuclear Power (April 1980). The Koeberg Nuclear Reactor (a 2-unit pressurized-water-reactor or PWR) at the time was under-construction, 27km from Cape Town, near Duynefontein on the west coast of South Africa. Subsequently the reactor was connected to the national grid in 1984/5. The author, a senior lecturer in physics at UCT (1977/80), created interest by providing the only reply to a Cape Town resident's misleading claims regarding the safety of US reactors in a Letter to the Editor ('US report on nuclear plants is horrifying') published in the Cape Argus (The 'Argus', Cape Town) newspaper on the 1 June 1979. The author's letter in reply ('Risks from nuclear power small'), based on two referenced US reports, was published on the 18 June 1979. This led to speaking invitations at two public symposia at UCT. This poster displays copies of Letters to the Editor and news reports from the Argus and the Cape Times (Cape Town) newspapers, as well as UCT letters. The author was a speaker, 28 January 1980, at the very successful UCT Summer School Symposium 'Why Koeberg?', speaking on the topic 'Properties of Pressurized Water Reactors' attended by approximately 100 members of the general public. In all, over the period 28 January to 8 February 1980, there were 7 Summer School speakers and a final panel discussion, after which, in a vote, the majority of the attendees felt the building of the Koeberg Nuclear Power Station was justified. The author gave a similar presentation during the UCT Science Students Council's Symposium on Nuclear Power, 7 April to the 11 April 1980. This poster's aim is to inform young physicists about opportunities that came about for the author (a physicist) from publicity for the Koeberg Nuclear Power Station, under-construction, near Cape Town during 1979/80. In 1977 nuclear power use was being considered in NZ (e.g., 'Nuclear Power by 2000 - report', Hawkes Bay Herald Tribune, 3 June 1977). Perhaps a nuclear reactor will be considered by 2050. A physicist can help provide a balanced and factual view in informing the public about reactor design and safety issues.

Spatio-temporal Solitons in Cylindrical Resonators

Brand C[1,2], Murdoch S[1,2]
[1]University Of Auckland, Auckland, New Zealand
[2]The Dodd Walls Centre, New Zealand

Biography:
I'm currently an honours student in physics at the University of Auckland in the group of Stuart Murdoch, working in the field of nonlinear fibre optics. I have just completed my BSc at the University of Auckland in physics and Maths.

Solitons are solitary waves that propagate unchanged, maintaining both speed and shape. They form through either the interplay of dispersion and nonlinear effects in the temporal domain, or diffraction and nonlinearity in the spatial domain. Temporal solitons can be excited in optical resonators such as fibre ring resonators and microresonators and have attracted much recent attention for their ability to generate optical frequency combs. But can we generate these solitons in more than one dimension?
A long thin cylinder such as an optical fibre can be used as a microresonator where light can propagate around the circumference as well as along the length of the cylinder. The lack of axial confinement along the cylinder allows light that is evanescently coupled into the resonator to diffract out along the length of the cylinder. In theory, this platform should thus allow for the generation of two-dimensional localised structures such as solitons both along the length of the cylinder and in the temporal dimension due to the Kerr nonlinearity. In practice, we can also drive the cylinder with a tapered fibre which gives a spatially strongly localised driving field. This localised driving yields a spatially confined field that may aid soliton formation, and displays interesting dynamics depending on the characteristics of the cylinder.
This poster will discuss the theory behind the resonant modes of the cylindrical microresonator as well as simulation and experimental results for driving cylinders with different lengths and diameters. Using a cylinder as a resonator allows us to test a large range of parameters such as the diameter, length, material and tilt of the cylinder. Additionally, by adjusting the power of the input laser, we can tune how strong the nonlinear effects are and can observe the behaviour both with and without nonlinear effects.
All of these adjustable parameters provide a great testing ground for the generation of frequency combs. Frequency combs are laser light sources whose spectrum is composed of equidistant lines and can be created from the periodic pulses generated by solitons traversing the resonator. They have a great number of applications ranging from spectroscopy to telecommunications to the detection of extra solar planets so we wish to improve our understanding of frequency comb generation.

Investigating Reversible Assemblies of Janus Particles

Chung S[1,2], Latif Q[1,2], Willmott G[1,2,3]
[1]MacDiarmid Institute for Advanced Materials and Nanotechnology, [2]Department of Physics, The University of Auckland, New Zealand, [3]School of Chemical Sciences, The University of Auckland, New Zealand

Biography:
I am currently a first year PhD student from the University of Auckland, studying Janus particle interactions by suspending them in microfluidic channels.

Colloidal self-assembly is a powerful strategy for developing technologies where nano- or micro-scale particles self-organise into structures with emergent properties1,2. One particular type of particles of interest is asymmetric colloids known as Janus particles. The anisotropic nature of these particles introduces directionality in particle-particle interactions3 and for amphiphilic particles these interactions are dominated by hydrophobic attraction4. However, further study is needed to better understand the dynamics of these interactions, and how they are influenced when Janus particles are suspended in a microfluidic channel with continuous flow.
In the present work, we study the dynamics and assemblies of Janus particles inside a sheath-flow microfluidic channel. We use polystyrene and silicon spheres as our base particles to create amphiphilic Janus particles with sizes visible using optical microscopy (4-10 µm). Amphiliphilicity is created by depositing gold on these spheres prior to functionalisation with thiol groups. Our sheath-flow microfluidic channel is tested using COMSOL with the computational fluid dynamics module before fabricating them using soft lithography. We characterise particle-particle interactions by their orientation as a function of position through the microfluidic channel, and our latest results and analysis of these experiments will be presented.

References

1.Li, F., & Josephson, D. P. Angew. Chem. Int. Ed. 50 (2011) 360-388.
2.Vogel, N., Retsch, M., Fustin, C. -A., & del Campo, A. Chem. Rev. 115 (2015) 6265-6311.
3.Jiang, S., Chen, Q., Tripathy, M., Luijten, E., Schweizer, K. S., & Granick, S. Adv, Mater. 22 (2010) 1060-1071.
4.Hong, L., Cacciuto, A., Luijten, E., Granick, S. Langmuir 24 (2008) 621-625.

Photoluminescence-based temperature sensing using sensitised fluoroperovskite nanoparticles

Devane H[1], Chong S[1,2]
[1]Robinson Research Institute, Lower Hutt, New Zealand, [2]Victoria University of Wellington, Kelburn, New Zealand

Biography:
I've been studying my masters of science in physics at Robinson Research Institute for 3 months now. Prior to this, I completed my undergrad and honours years in Dunedin at the University of Otago.

This research aims to investigate the use of doped fluoroperovskites as a potential wireless photoluminescence-based temperature sensor for power grid monitoring in New Zealand. Wired sensors currently used in power grid monitoring are prone to damage from power surges due to the high current induced in their wires. Therefore, wireless sensing is critical for the reliability and longevity of the sensors. The project focuses on characterising the fluoroperovskite NaMgF3 (prepared as nanoparticles) doped with varying concentrations of Europium to determine which concentration exhibits the ideal temperature-dependent behaviour necessary for a wireless temperature sensor. The nanoparticles are first prepared through a hydrothermal synthesis, and are then sensitized with a ligand (thenoyltrifluoroacetone) to dramatically increase their photoluminescence. The characterisation process will involve determining the structure through XRD, and the luminescent properties through photolumiescent (PL) spectroscopy, for each concentration. Preliminary XRD results have shown potential defects in the crystal structure with increasing Europium concentration, and preliminary PL spectroscopy results have shown a non-linear increase in the intensity of the PL spectrum with increasing europium concentration. Once characterization has been completed, the temperature dependent behaviour of these samples and their corresponding PL spectra will be investigated. This research is expected to contribute to the development of a reliable and efficient wireless temperature sensor for power grid monitoring.

Detection of dislocation motion in atomistic simulations of nanocrystalline materials

Firman Dimanstein N[1], Engelberg E[2]
[1]Hebrew University Jerusalem, Jerusalem, Israel, [2]Jerusalem College of Engineering, Jerusalem, Israel

Biography:
Eliyahu Zvi Engelberg
Ph.D in Physics from Racah Institute of Physics, Hebrew University, Jerusalem, Israel
Lecturer in Jerusalem College of Engineering
Noya Firman Dimanstein
B.Sc. in the Combined Program in Exact Sciences – Physics Emphasis and M.Sc. in Physics, Racah Institute of Physics, Hebrew University, Jerusalem, Israel
Ph.D candidate Physics from Racah Institute of Physics, Hebrew University, Jerusalem, Israel

Plastic response of metals to applied stress is often controlled by dislocation dynamics. Modelling such processes, therefore,
depends on developing an understanding of these dynamics,
and how they are modified by externally applied conditions and material properties. In most cases, however, direct observation of dislocation dynamics is impossible. Therefore, alternative methods are required to analyze the characteristics of dislocation dynamics.
One such method is running molecular dynamics (MD) simulations of plastic processes, and inferring the details of the dislocation dynamics from these simulations.
We present a method for identifying dislocation motion in atomistic simulations. While identifying static and moving dislocations within a single crystal or a combination of such is well-established, the method described here is targeted to identify dislocation motion through correlation in the individual atom displacement. This holds the premise of enabling the identification of dislocation motion in complex scenarios.
The method is applied to test cases in crystals and grain boundaries, in which irradiation-induced creep was induced. It is shown that the method singles out the mobile dislocations from among the dislocation forest at grain boundaries, thus identifying the specific reactions driving the distortion at any given time. This enables the study of dislocation processes in the presence of realistic obstacles, and the study of the effects of microstructure on dislocation mobility.

How the piezochromism of copper molybdate can potentially be utilised to improve magnetic sensing techniques

Fowler J[1,2], Chong S[1,2,3], Williams G[1,2,3]
[1]Robinson Research Institute, Lower Hutt, New Zealand, [2]Victoria University of Wellington, Wellington,, New Zealand, [3]MacDiarmid Institute, Wellington, New Zealand

Biography:
Jackson is a MSc student studying at Paihau-Robinson Research Institute under Shen Chong and Grant Williams. This is a 12 month course that he started in late February. He graduated last year from the University of Otago with a BSc(Hons) degree majoring in physics and minoring in mathematics. This is his first time at the NZIP conference and he is very grateful for the opportunity to be here.

The current strain on New Zealand's electric grid will only increase as we progress towards our goal of a carbon neutral future and electric transport methods become more commonplace. More reliable and precise sensing techniques are needed to combat this increased dependency to allow us to detect faults before they become catastrophic. Our team at Robinson Research Institute is investigating a proposed novel sensing technique where piezochromism is coupled with magnetostriction to create magnetochromism (changing colour depending on magnetic field intensity). This would allow us to wirelessly measure the magnetic field strength through a simple optical inspection of the compound. My role in this project is investigating copper molybdate ($CuMoO_4$) which is an established exhibitor of piezochromism as it undergoes a first-order structural phase transition under pressure that changes the colour of the compound from a light-green to a reddish-brown. I have been initially working on synthesis and characterisation of copper molybdate; with a specific focus on the aforementioned phase transition. Following this I will transition onto attempting to achieve coupling between my synthesised copper molybdate samples and some magnetostrictive compound; this is at present the primary goal of this research project. In this poster I will present my current findings detailing the points of interest, furthermore, I will elaborate on my future plans for this project and lay out the proposed methods to achieve my final goals.

Exploring more flexible boundary conditions for melting simulations of noble gas nanoclusters in strong magnetic fields

Hussain A[1], Hunter G[1], Pahl E[1]
[1]The MacDiarmid Institute for Advanced Materials and Nanotechnology, Department of Physics, University of Auckland

Biography:
Malaaha Hussain is in her last year of a Bachelor of Advanced Science specialising in Physics. Her Honours project in condensed matter focuses on using Monte Carlo methods to simulate the melting of noble gas nanoclusters.

Magnetic white dwarfs are an example of a hitherto unexplored extreme environment, with their strong magnetic fields drastically altering the properties of the materials that make up their atmospheres. Noble gases such as neon are of particular interest in this case as the diamagnetic and paramagnetic effects produced by the star's magnetic field cause nanoclusters of these noble gases to become squeezed into more elliptical configurations, owing to the strengthening of the dimer bonds within them. This, combined with the abundance of these noble gases in the atmosphere, provides motivation for us to study the possible phase transitions that may occur in this extreme environment.
The phase transition that I am most interested in is the melting of these clusters, which is simulated in Julia using the Parallel Tempering Monte Carlo method. In the current program, a spherical boundary is implemented around the cluster to stabilise it and prevent atom loss from occurring. However, this is not the most ideal method to use in strong magnetic fields such as those observed on magnetic white dwarfs due to the more elliptical shape of the clusters. The focus of my research is in introducing and exploring the adjacency boundary condition, which defines an atom as part of the nanocluster by the number of atoms within the nanocluster it is bonded to, rather than confining the cluster within a sphere. The flexibility that this new condition provides allows us to investigate the melting of elliptical clusters more efficiently and effectively.

Accessing the Unseen World of Matter

Murcott A[1], Yu D[1], Pahl E[1]
[1]The MacDiarmid Institute for Advanced Materials and Nanotechnology, Department of Physics, University of Auckland

Biography:
Abigail is a PgDipSci student in Condensed Matter Physics at the University of Auckland.

When our questions about the world exceed the limits of what we can realistically produce in a lab, we can turn to computer simulations to give us insight into the "hard-to-reach" areas of science. In the case of condensed matter research, phase transitions simulations allow us to investigate the behaviour of materials under extreme conditions, such as high pressures or strong magnetic fields that can only be found in outer space.
A Monte-Carlo melting simulation explores how a system of atoms in a cluster traverses phase-space as it evolves over time and increasing temperature. However, the quality of such a program must be carefully checked to ensure a good representation of this space is produced. Our goal is to test the Monte-Carlo simulation for ergodicity - its ability to sample all of configurational space - and to visualise this exploration using Common Neighbour Analysis methods to produce "bird poo" plots of stable configurations which allow us to extract information at a glance about the behaviour of materials in different environments.

Demonstrating the Magnetic Memory Function of Tri-Layer Thin Films Using Rare-Earth Nitride Solid Solutions

Pot C[1], Ruck B[1], Holmes-Hewett W[1], Trodahl J[2]
[1]Victoria University Of Wellington and The MacDiarmid Institute for Advanced Materials, Wellington, New Zealand, [2]Victoria University Of Wellington, Wellington, New Zealand

Biography:
Catherine Pot is a PhD student in Physics at Victoria University of Wellington. Her work focuses on using rare-earth nitrides to make magnetic memory devices. Catherine's work is based on previous fundamental research done in the spintronics group at Victoria and applying the magnetic and electrical properties of rare-earth nitrides to develop device structures and reading methods.

Historically, magnetic memory underpinned most computing designs. The push towards low temperature computing requires the development of compatible memory elements for the relevant operating conditions. The typical tri-layer magnetic memory structure comprises of two ferromagnetic layers separated by a non-magnetic blocking layer and the rare-earth nitride series provides much promise as suitable ferromagnetic materials. Rare-earth nitrides have a wide range of magnetic properties which can be tuned separately to the electrical properties. Solid solutions such as (Gd,Sm)N with varying Gd concentrations allow for the desired magnetic properties to be selected. To distinguish binary states, the ferromagnetic layers in the tri-layer are set to either be aligned or anti-aligned where the orientation of one layer is independently switched. Here, the process of magnetically writing and reading the state of tri-layer thin films with varying Gd concentrations in the ferromagnetic layers is demonstrated.

Direct conversion of optical to electrical signals using a Ce:YAP scintillator coated with a TiO2 photoconductive sensor

Raduban M[1,2], Olejníček J[3], Kohout M[3], Hubička Z[3], Yamanoi K[2], Hayashi T[4], Ozawa G[4], Ono S[4]
[1]Centre for Theoretical Chemistry and Physics, School of Natural Sciences, Massey University, Auckland, New Zealand, [2]Institute of Laser Engineering, Osaka University, Suita, Japan, [3]Institute of Physics, Czech Academy of Sciences, Prague, Czech Republic, [4]Department of Physical Science and Engineering, Nagoya Institute of Technology, Nagoya, Japan

Biography:

Dr. Marilou Cadatal-Raduban is a Senior Lecturer at Massey University's School of Natural Sciences in Auckland, New Zealand. She is also a Specially Appointed Associate Professor at Osaka University Institute of Laser Engineering in Japan. Dr. Cadatal-Raduban obtained her PhD degree in Physics from the Graduate University for Advanced Studies in Japan. Her research interests include modelling of material properties using density functional theory; numerical and experimental characterization of solid-state sensors and scintillators based on crystals, glasses, and thin films; effects of ionizing radiation on material properties; development of semiconductor and wide band gap photodetectors; and spectroscopy of optical materials.

Vacuum ultraviolet (VUV) radiation that spans the wavelength range from 200 nm down to 100 nm is indispensable in numerous technological applications, such as surface treatment, photochemical processing, optical cleaning of semiconductor substrates, and sterilization of medical apparatus. It is also important for scientific research, primarily in gas chromatography and molecular spectroscopy, for example, to probe carbon–carbon and nitrogen–nitrogen triple bonds in alkynes. In recent years, tremendous research has gone into the development of VUV light sources to meet these technological and scientific demands. Development of detectors for this short wavelength region is as crucial, to match the rapid progress. Scintillators such as trivalent cerium ion-doped yttrium aluminum perovskite (Ce:YAP) are luminescent materials that absorb incident high-energy radiation, converting it into more accessible optical wavelengths through the emission of photons (photoluminenscence or PL) having energies in the UV or visible region. As such, scintillators are the main sensing units in VUV detectors. However, a separate photodetector is needed to detect the PL emitted by the scintillator by converting it to electrical signals. In this work, we present the development of a hybrid Ce:YAP scintillator by coating the scintillator's surface with a titanium dioxide (TiO_2) thin film. The TiO_2 film serves as a photoconductive sensor that directly converts the PL emission from Ce:YAP to electrical signals, thereby eliminating the need for an external photodetector. TiO_2 was reactively sputtered in Ar/O_2 atmosphere on the surface of Ce:YAP using DC hollow cathode discharge. A titanium rod with outer and inner diameters 12 and 5 mm respectively was used as the target. The TiO_2 film was deposited under working pressure of 1 Pa, and discharge current of 1.5 A. The distance from the hollow cathode to the Ce:YAP substrate was set to 10 cm to ensure homogeneity. The deposition rate was 7 nm/min, corresponding to about 30 minutes of deposition time for a 200-nm thick TiO_2 layer. The effect of heating the Ce:YAP substrate during sputtering and annealing of the Ce:YAP-TiO_2 hybrid scintillator post-TiO_2 deposition was investigated. The PL emission spectrum from Ce:YAP broadened while the peak wavelength shifted to shorter wavelengths after annealing. The shift resulted to a greater overlap between the absorption spectrum of TiO_2 and the PL emission of Ce:YAP. Annealing also improved the crystallinity of the TiO_2 photoconductive thin film. Development of this hybrid scintillator will pave the way to miniaturization of scintillators for the detection of high-energy radiation.

Electronic circuitry for shaping current pulses for small-scale transcranial magnetic stimulation (TMS) coil

Raju S[1], Wilson M[1], Kularatna N[1]
[1]University Of Waikato, Hamiton, New Zealand

Biography:
Soniya Raju was born in Kerala, India. She received a B.Tech. (Hons.) degree in electrical and electronics from the Mahatma Gandhi university in Kerala, in 2014, and the M. Tech degree in power electronics and drives from the Karunya University, Tamil Nadu in 2016.
Soon after her master's, she started her teaching career in India for 5 Years. she is currently pursuing Ph.D. at Waikato university.

TMS, Transcranial Magnetic Stimulation, works on the principle of Faraday's law of electromagnetic induction. A time-varying current-carrying coil placed on the surface of the brain produces a magnetic field. This magnetic field which permeates a conductive medium (e.g., brain tissue), can induce an electric current in the tissue. So, this induced magnetic field may produce an eddy current in the brain sufficient to stimulate the axon hillock of each neuron. While human TMS coils have been well-analyzed, small animal TMS coils are less explored. This is a challenging area because of the small size coil. My research is to develop an electronic circuit that produces a time-varying pulse with a controllable shape (amplitude, decay time, profile) and evaluate its effects on neuronal stimulation. We aim to find an optimized relation between the pulse shape and field so that we can predict what type of pulse (in time, shape, and duration) is optimal for a particular TMS application. We are designing a high voltage high current pulse generator in general. We have developed a high-voltage pulse (up to 600 V from a 5 V supply) from a supercapacitor using a designed step-up transformer and are in the stage of energizing the coil using a high-current pulse (~200 A) from it. We will later optimize the pulse shape. It is important to note that there is a balance to maintain between each of the parameters (like developing a high current pulse with low heating losses, short duration pulse which can produce high field intensity, etc) and this research is to optimize the possibilities and produce a current pulse for the TMS coil. We aim to design a simple and efficient common circuit that can be used for small animal research but opens up many avenues for research on brain simulation.

Free Space Optical Communications in New Zealand

Rattenbury N[1], Bennet F[5], Cater J[2], Dlubatz M[3], Fuchs C[3], Giggenbach D[3], Jain H[3], Kalkhof A[3], Knopp M[4], Müller T[3], Qualtrough C[1], Rittershofer J[3], Walker K[1], Weddell S[2]
[1]The University of Auckland, Auckland, New Zealand, [2]The University of Canterbury, Christchurch, New Zealand, [3]Deutsches Zentrum für Luft- und Raumfahrt, Munich, Germany, [4]German Space Operations Center, Munich, Germany, [5]Australian National University, Canberra, Australia

Biography:
Dr Nicholas Rattenbury is a member of the Japan-NZ-US group the Microlensing Observations in Astrophysics (MOA) collaboration, the NZ COSPAR committee, the Strategic Leadership group for Te Pūnaha Ātea Space Institute, the Executive for the Te Ao Mārama Centre for Fundamental Inquiry, the Chair of the NZ National Organising Committee for the International Astronomical Union and a former President of the Royal Astronomical Society of New Zealand.

The radio frequency (RF) spectrum is becoming increasingly crowded and is under pressure from spacecraft operators demanding higher bandwidth for their missions. Communicating between space and ground at near infrared wavelengths offers an increase in bandwidth and increased security. Research is underway in New Zealand into developing free-space optical communications as a viable alternative and disruptive technology in ground segment provision. I will describe the current state of this research, the challenges faced by FSOC, how we are meeting those, and the research collaborations we have established with the Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center), the Australian National University and the University of Western Australia as part of the Australasian Optical Ground Station Network.

Professional and Amateur Astronomy and Astrophysics

Rattenbury N[1], Love T[2], Brito N[2]
[1]The University of Auckland, Auckland, New Zealand, [2]The Royal Astronomical Society of New Zealand, New Zealand

Biography:
Dr Nicholas Rattenbury is a member of the Japan-NZ-US group the Microlensing Observations in Astrophysics (MOA) collaboration, the NZ COSPAR committee, the Strategic Leadership group for Te Pūnaha Ātea Space Institute, the Executive team for the Te Ao Mārama Centre for Fundamental Inquiry, the Chair of the NZ National Organising Committee for the International Astronomical Union and a former President of the Royal Astronomical Society of New Zealand. He is a Senior Lecturer in Physics at The University of Auckland.

A recent survey was undertaken by the Royal Astronomical Society of New Zealand on what support could be useful to foster links between amateur and professional astronomers. New Zealand has a long history of high-quality astronomy work done by people whose primary employment is not in that arena. The interest and energy of that amateur community has long been acknowledged and the quality of the work is often consistent with that recognised by international peer-review as fit for publication. I will summarise the survey results and provide suggestions for how the amateur and professional astronomy communities could work more effectively together.

Space Physics Research at The University of Auckland

Rattenbury N[1], Austin A[1], Balkenhohl J[1], Caldarelli A[1], Cater J[2], Filleul F[1], Graham D[1], Nieke P[1], Weaver T[1], Zhang A[1]
[1]The University of Auckland, Auckland, New Zealand, [2]The University of Canterbury, Christchurch, New Zealand

Biography:
Dr Nicholas Rattenbury is a member of the Japan-NZ-US group the Microlensing Observations in Astrophysics (MOA) collaboration, the NZ COSPAR committee, the Strategic Leadership group for Te Pūnaha Ātea Space Institute, the Executive team for the Te Ao Mārama Centre for Fundamental Inquiry, the Chair of the NZ National Organising Committee for the International Astronomical Union and a former President of the Royal Astronomical Society of New Zealand. He is a Senior Lecturer in Physics at The University of Auckland.

I will briefly describe some of the space physics research projects underway at The University of Auckland. These include (i) Plasma propulsion for spacecraft, (ii) Trajectory optimisation for low-delta-v spacecraft manoeuvres, (iii) Optimisation of additive manufactured 3D printed heat-shielding materials for space mission return applications, (iv) space domain awareness observations for safe spacecraft operations and planetary defence, (v) NZ Space policy and sector development, (vi) Synthetic aperture radar for the monitoring of NZ’s exclusive economic zone.

Discovering Extrasolar Planets with the MOA, PRIME, Roman and CLEoPATRA Telescopes

Rattenbury N[1]
[1]The University of Auckland, Auckland, New Zealand

Biography:
Dr Nicholas Rattenbury is a member of the Japan-NZ-US group the Microlensing Observations in Astrophysics (MOA) collaboration, the NZ COSPAR committee, the Strategic Leadership group for Te Pūnaha Ātea Space Institute, the Executive team for the Te Ao Mārama Centre for Fundamental Inquiry, the Chair of the NZ National Organising Committee for the International Astronomical Union and a former President of the Royal Astronomical Society of New Zealand. He is a Senior Lecturer in Physics at The University of Auckland.

New Zealand has been discovering extra-solar planets through gravitational microlensing for over 25 years. The country's largest telescope is operated by the Microlensing Observations in Astrophysics (MOA) collaboration and monitors fields in the Galactic bulge and Magellanic Clouds for microlensing events. MOA alerts the global community when these events occur. Anomalies in these events which could be owing to extrasolar planets are intensely monitored. The latest evolution of extrasolar planet detection will be the use of NASA's Nancy Grace Roman telescope, which will detect planets using gravitational microlensing from space for the first time. The MOA collaboration has a new initiative, called PRIME, which is also the name of a new 1.8m telescope operating in South Africa. PRIME will take IR observations of potential target fields to refine the choice of fields for the Roman telescope. I will describe the MOA and PRIME collaborations, as well as the Roman search for extrasolar planets. I will also describe the Contemporaneous LEnsing Parallax and Autonomous TRansient Assay (CLEoPATRA) space mission concept which is designed to provide variable-baseline simultaneous microlensing parallax measurements for the Roman space telescope.

Hafnium Nitride, an occasional superconductor

Trewick T[1], Holmes-Hewett W[1], Trodahl J[2], Ruck B[1]
[1]The MacDiarmid Institute for Advanced Materials and Nanotechnology and The School of Chemical and Physical Sciences, Victoria University of Wellington, PO Box 600, Wellington 6140, New Zealand,
[2]The School of Chemical and Physical Sciences, Victoria University of Wellington, PO Box 600, Wellington 6140, New Zealand

Biography:
Ted Trewick is a PhD candidate in the School of Physical and Chemical Sciences at Victoria University of Wellington. He is attempting to study the properties of the rare earth nitrides and integrate these in superconducting devices using a variety of experimental and computational techniques, including XRD, magnetometry, and DFT.

The rare earth nitrides (RENs) are a family of intrinsic ferromagnetic insulators, and have undergone intense investigation for their potential applications in devices. In particular, there is interest in the integration of these materials in superconducting circuits as it has been theorised that an insulating barrier in superconductor/ferromagnet/superconductor junctions would allow the realisation of qubits with higher coherency than with a metallic barrier [1]. Performant devices require defect free materials, best produced by epitaxial growth, requiring lattice matching from substrate - superconductor - REN - superconductor. This can be achieved using a hafnium nitride superconducting layer grown on (001) silicon [2]. This study investigates the synthesis of HfN films by molecular beam epitaxy, and subsequent characterisation using scanning electron microscopy, energy dispersive X-ray spectroscopy , and X-ray diffraction to confirm the crystal structure and composition of the material. The temperature dependant resistivity of samples is measured and correlated with hafnium vacancy doping, and the superconducting transition observed in stoichiometric films.

[1] Kawabata, S.; Kashiwaya, S.; Asano, Y.; Tanaka, Y.; Golubov, A. A. Macroscopic Quantum Dynamics of π Junctions with Ferromagnetic Insulators. Phys. Rev. B 2006, 74 (18), 180502. https://doi.org/10.1103/PhysRevB.74.180502.
[2] Satoko Shinkai, S. S.; Katsutaka Sasaki, K. S. Influence of Sputtering Parameters on the Formation Process of High-Quality and Low-Resistivity HfN Thin Film. Jpn. J. Appl. Phys. 1999, 38 (4R), 2097. https://doi.org/10.1143/JJAP.38.2097.

Defect-activated vs. intrinsic Raman spectra of GdN and LuN

Van Koughnet K[1], Trodahl J[1], Holmes-Hewett W[2], Ruck B[1]
[1]School of chemical and physical science, Victoria University of Wellington, New Zealand, [2]Robinson Research Institute, Victoria University of Wellington, New Zealand

Biography:
Kiri Van Koughnet is a PhD candidate at Victoria University of Wellington studying the electronic and magnetic properties of rare earth nitrides. She has completed two summer research projects at Robinson Research Institute and VUW relating to growth and characterisation of rare earth nitride thin films. She also has spent the last two years working part-time alongside her studies as a research assistant at Robinson Research Institute focusing on optical spectroscopy.

The vibrational excitations in the rare-earth nitrides (as in all crystalline solids) have a defining influence on their thermal properties, but techniques for their full characterisation are substantially limited compared to those for electronic excitations. The most common study, infrared absorption spectroscopy, has yielded the frequency of only the infinite-wavelength transverse optic mode [1], no more than a single point of comparison with computed vibrational frequencies. The common second measurement, Raman scattering by phonons, is forbidden in the NaCl structure adopted by the materials. Nonetheless we find a density-of-modes pattern expected for nearly point-defect scattering, an intrinsic two-phonon scattering spectrum, and an LO mode, the origin of which has been a puzzle for a decade [2,3].
In this poster we will present a full study of inelastic Raman scattering with incident photons spanning the visible. The results are compared with the phonon dispersion and density-of-modes calculated within an LSDA+U treatment indicating that computed phonon frequencies are marginally (a few %) smaller than measured, with the disagreement rising to ~30% for the TA branch. The longitudinal optic feature relates to similarly anomalous features in Eu monochalcogenides (including EuO), however, the magnetic-scattering model used for the Raman activity in those compounds is insufficient for these materials. Here we suggest the source of the symmetry forbidden scattering in the rare-earth nitrides, in disagreement with previous ideas [4].

[1] W.F. Holmes-Hewett, R.G. Buckley, T.J. Butler, C. Pot, K. Van Koughnet, B.J. Ruck, and H.J. Trodahl, AIP Adv. 12, 075120 (2022).
[2] S. Granville, C. Meyer, A.R.H. Preston, B.M. Ludbrook, B.J. Ruck, H.J. Trodahl, and W.R.L. Lambrecht, Phys. Rev. B 79, 054391 (2009).
[3] K. Upadhya, R. Kumar, Q. Li, B. Sun, and B. Saha, Phys. Status Solidi RRL 16, 2200029 (2022).
[4] K. Van Koughnet, H.J. Trodahl, W.F. Holmes-Hewett, and B.J. Ruck, manuscript submitted for publication.

Using field trips as undergraduate student mental wellbeing and engagement tools

Whittaker I[1], Baldwin K[1], Evans N[1], Fairhurst D[1]
[1]Department of Physics - Nottingham Trent University, Nottingham, UK

Biography:
Dr Whittaker is a senior lecturer in physics teaching modules directly related to Physics with Astrophysics degree stream for undergraduate study. In 2019 Dr Whittaker won the Sir Paul Curran Award for Academic Communication from the The Conversation. His current public science profile also includes articles in national newspapers, BBC Frontiers magazine, and Physiology Today. His current readership in The Conversation is over 4 million and he is the most read author from NTU. In 2021 Dr Whittaker won the Vice Chancellors Outstanding Teaching Award for an Early Career Teacher, and also the NTSU Teaching Award for Science and Technology.

With the relaxation of lockdown rules in the UK we have seen a marked decrease in undergraduate attendance, and engagement. This is not unique to any particular institution, or to higher education, but is of a general rising concern as the 'COVID generation' have had different periods of their education compromised.
In this talk we will describe three field trips that have occurred in the last year and the effects these have had on the students, as well as notes on impacts these have had on future plans. The first trip was a 4 day long residential dark skies field trip to Northern Ireland. The other two were single day trips; one linked to the first-year undergraduate curriculum, and the other linked to industry challenges and employability prospects. Data collected from these trips have focused on the benefits to mental wellbeing and importance of application to learning, as well as informing us of the importance of the right mode of travel.
We will present what has worked well, and just as importantly, what has not worked well, in order to build an ideal template for a student-engaging field trip.