Faculty of Science
Summer Research Scholarships

2026/2027 Projects (Physics)

Project code	SCI072
Project title	**Quantum Matter and Light**
Discipline	Physics
Supervisor(s)	A.-Prof. Scott Parkins
Contact details	s.parkins@auckland.ac.nz
Skills Needed	• Knowledge of quantum physics at Stage 2/3 level • Good background in calculus and algebra • Programming experience with Python or Matlab

Project description

This is a project in theoretical quantum optics, with particular emphasis on cavity quantum electrodynamics (cavity QED) – the interaction of atoms with quantised light fields inside optical resonators. Our specific interest is in the controlled preparation of uniquely quantum-mechanical states of both atoms and light fields. Such states are of interest from a fundamental point of view as well as being of basic importance in the topical fields of quantum information processing (e.g., quantum communication and computing) and many-body quantum physics. The project will involve a combination of analytical and numerical calculations using simple models and established techniques of theoretical quantum optics.

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Summer Research Scholarships

2026/2027 Projects (Physics)

Project code	SCI073
Project title	**Drop Impacts and Capillarity**
Discipline	Physics
Supervisor(s)	Prof. Geoff Willmott Dr Mohammed Abdelbassit
Contact details	g.willmott@auckland.ac.nz
Skills Needed	• Good written and verbal communications skills • Interest and good track record in related academic topics

Project description

Experimental projects are available to study microscale liquid dynamics using high-speed photography (producing cool slow-motion videos). We are particularly interested in drop impact experiments, in which drops collide with solid surfaces. Fluids of interest include partially dried dairy products, and ferrofluids which produce 'spiky' magnetic instabilities. Surfaces may be patterned in order to control the spreading, splashing and rebounding of the drops. A project could also focus on development of image analysis techniques.

Projects are suitable for students from any quantitative science / engineering background, and can be aligned with industrial (real-world) applications. Skills developed will include experimental methods for materials science, and understanding of fluid dynamics.

Lab website: https://fluidics.physics.auckland.ac.nz/

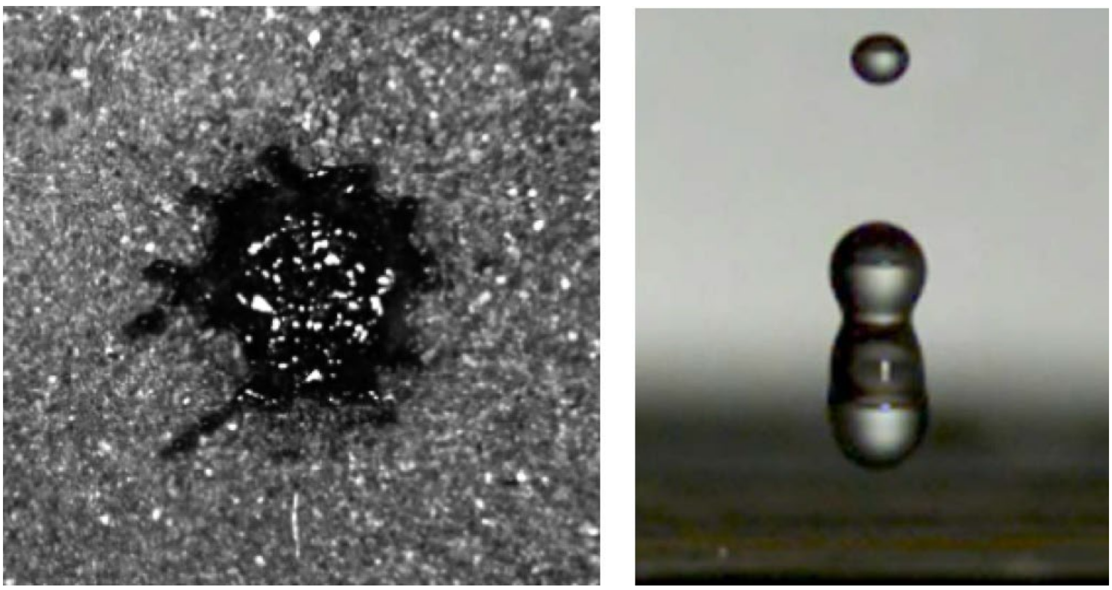

Figure: Examples of water drop impact outcomes on (left) a granular surface, top-down view; and (right) a superhydrophobic surface, side view.

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Summer Research Scholarships

2026/2027 Projects (Physics)

Project code	SCI074
Project title	**Soft Matter Models (Theory / Computational)**
Discipline	Physics
Supervisor(s)	Prof. Geoff Willmott
Contact details	g.willmott@auckland.ac.nz
Skills Needed	• Good written and verbal communications skills • Interest and good track record in related academic topics

Project description

Projects are available to develop and use computational analysis methods and/or theoretical models to study two interesting soft matter systems.

(i) Assemblies of asymmetric Janus spheres, which consist of two hemispheres with distinct properties. Computational methods will be used to study the how Janus microspheres approach each other in microfluidic flows, and their relative orientation within small clusters. Understanding of how these microparticles can be assembled into larger-scale structures can assist with creation of new sustainable materials.

(ii) Soft microparticles (e.g. cells) undergoing deformation within a constriction. This work is relevant to development of new methods for easily analysing the mechanical (or more fully, rheological) properties of such particles.

Computational / numerical projects are especially suitable for students with some relevant experience.

Lab website: https://fluidics.physics.auckland.ac.nz/

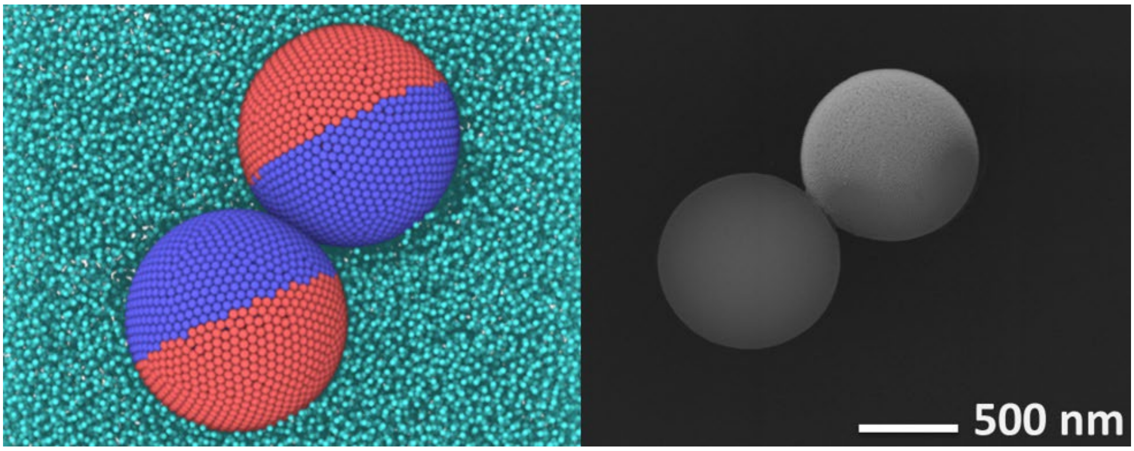

Figure: Dimers of Janus particles represented in (left) a computational simulation; and (right) SEM imaging of gold-capped polystyrene colloids.

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Summer Research Scholarships

2026/2027 Projects (Physics)

Project code	SCI075
Project title	**Acoustically Levitated Droplets**
Discipline	Physics
Supervisor(s)	Prof. Geoff Willmott
Contact details	g.willmott@auckland.ac.nz
Skills Needed	• Good written and verbal communications skills • Interest and good track record in related academic topics

Project description

Project(s) are available to study levitating droplets in the Dynamic Microfluidics Lab. Drying of droplets as they drift through the air is a critical process for some of the most important scientific challenges of our times, including climate science and the spread of infectious diseases. The student would carry out experiments and/or analysis for droplets held by an acoustic levitator. This instrument can hold a droplet suspended in air while the surrounding atmosphere is controlled, allowing the kinetics of droplet nucleation, growth, and drying to be studied.

Lab website: https://fluidics.physics.auckland.ac.nz/

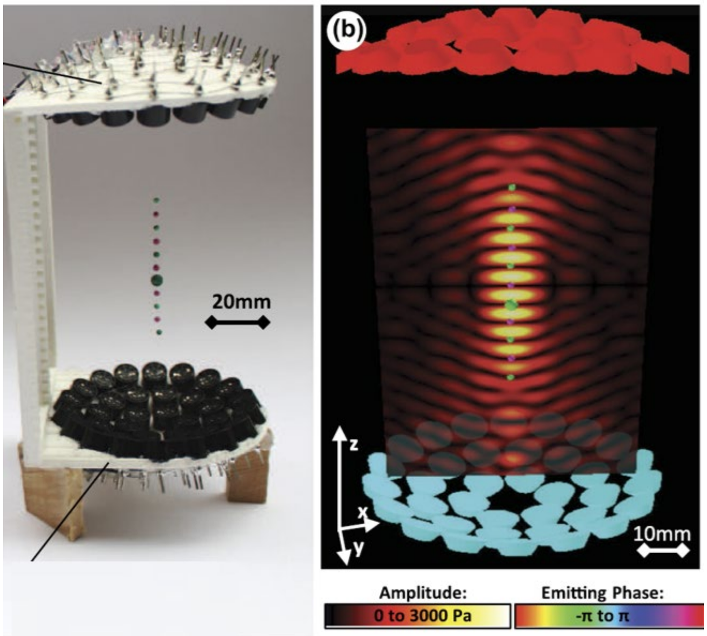

Figure: An acoustic levitator as used in the Dynamic Microfluidics Lab, image from Marzo et al., Rev. Sci. Instrum. **88,** 085105 (2017). Left: photograph of the levitator; right: simulated acoustic field.

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2026/2027 Projects (Physics)

Project code	SCI076
Project title	**Honey Quantification and Characterization in Beehives by Imaging Techniques**
Discipline	Physics & Chemistry
Supervisor(s)	Dr Francesco Merola Dr Michel Nieuwoudt
Contact details	francesco.merola@auckland.ac.nz
Skills Needed	• Good teamwork • Some basic knowledge of spectroscopy and data analysis tools • An interest in applications of science to environmental and social matters

Project description

Understanding honey and pollen levels and types in beehives is crucial for beekeepers. This is generally assessed “a posteriori”, i.e. once honey is collected. This Project’s aim is to characterize pollen carried by honeybees using microscopy and spectroscopy techniques such as FTIR (Fourier Transform Infra-Red) and Raman, providing accurate information on the hive honey composition before harvesting.

Field work may be part of the project.

Faculty of Science
Summer Research Scholarships

2026/2027 Projects (Physics)

Project code	SCI077
Project title	**Modelling Varroa Mite and Honey Bee Populations**
Discipline	Physics & Biology
Supervisor(s)	Dr Francesco Merola Dr Michelle Taylor (Bioeconomy Science Institute)
Contact details	francesco.merola@auckland.ac.nz
Skills Needed	• Good teamwork • Some knowledge of algorithm development • Experience in MATLAB and/or Python • An interest in applications of science to environmental and social problems

Project description

A photonic device based on laser technology is being developed to eliminate Varroa mites in beehives. This Summer Research project will develop a Varroa-bee population model to understand laser effectiveness at controlling varroa over seasons. This study will provide information on the minimum percentage of Varroa that needs to be controlled to prevent bee colony collapse.

The student will collaborate with Arizona State University, adapting their work based on a differential equation system to suit New Zealand environmental conditions and introducing a laser parameter. Key parts of this project will be developing the model and field testing its effectiveness alongside Bioeconomy Science Institute partner in Ruakura (Hamilton).

Project code	SCI078
Project title	**Parametric Oscillation in On-Chip Micro-Ring Resonators.**
Discipline	Physics
Supervisor(s)	A.-Prof. Stuart Murdoch Dr Ray Xu
Contact details	s.murdoch@auckland.ac.nz
Skills Needed	• Student who has taken either PHYS 202 and 203 and/or PHYS 333

Project description

In this project the student will investigate the operation of a new type of laser source: the on-chip optical parametric oscillator. These sources are capable of wideband tunable wavelength output, and under the correct operating conditions can generate squeezed light.

This project will involve the experimental investigation of parametric oscillation in a specially designed on-chip silicon-nitride micro-ring resonator.

The student will gain experience working in an experimental optics lab including the use of lasers, photodetection, and optical spectral analysis.

The project is funded by Quantum Technologies Aotearoa through an MBIE Catalyst grant.

Faculty of Science
Summer Research Scholarships

2026/2027 Projects (Physics)

Project code	SCI079
Project title	**Light-Based Analysis of Articular Cartilage**
Discipline	Physics
Supervisor(s)	Prof. Frédérique Vanholsbeeck Darven Murali Tharan (PhD candidate) Dr Marco Bonesi Dr Cushla McGoverin
Contact details	f.vanholsbeeck@auckland.ac.nz
Skills Needed	• An interest in using light to study biological samples (biophotonics) • Good organisational skills and attention to detail • Commitment to follow laboratory safety practices and protocols

Project description

Articular cartilage covers the ends of bones where they move against each other in the joint. This articular cartilage enables smooth movement and must withstand substantial mechanical loading. Water, proteoglycans, and collagen make up articular cartilage, and the collagen is organised in a specific way. Composition and collagen organisation contribute to the biomechanical properties of articular cartilage. When this chemistry and organisation is altered, such as what happens for people suffering osteoarthritis, the effectiveness of the articular cartilage is reduced and movement may become painful. Identifying early changes in articular cartilage will allow for greater chances of delaying or preventing progression of articular degeneration.

We are developing light-based methods to image the collagen organisation and measure the composition of articular cartilage. Specifically, we used polarisation sensitive optical coherence tomography and Raman spectroscopy. In this project, the student will collect and analyse data using these methods from a variety of bovine articular cartilage samples. Within the project the student will learn about these techniques and how to use this instrumentation. Further, the student will learn the basics of using LabView and Matlab or Python, and learn some basic image analysis and multivariate statistical methods.

Faculty of Science
Summer Research Scholarships

2026/2027 Projects (Physics)

Project code	SCI080
Project title	**Light-Based Analysis of the Round Window Membrane**
Discipline	Physics
Supervisor(s)	Prof. Frédérique Vanholsbeeck Dr Haruna Suzuki-Kerr Dr Marco Bonesi Dr Cushla McGoverin Supported by Suyash Mehta (PhD candidate)
Contact details	f.vanholsbeeck@auckland.ac.nz
Skills Needed	• An interest in using light to study biological samples (biophotonics) • Good organisational skills and attention to detail • Commitment to follow laboratory safety practices and protocols

Project description

The cochlea is a spiral-shaped structure in the inner ear that transforms sound vibrations into nerve signals. Understanding what happens in the cochlea is important for understanding hearing and for fixing problems when things go wrong. The round window is an opening into the cochlea and may be a way to access information about what is happening in the cochlea. The round window is covered by a membrane – the round window membrane. We are investigating this round window membrane to learn more about its structure and determine what information we can access through the membrane. To this end, we are using optical coherence tomography and spectroscopy. In this project, the student will record optical coherence tomography images and spectra from ovine round window membrane samples to contribute to our database. The student will also have the opportunity to apply image analysis and multivariate statistical methods to these data to determine characteristics of interest (e.g. membrane thickness).

Faculty of Science
Summer Research Scholarships

2026/2027 Projects (Physics)

Project code	SCI081
Project title	**Building an LED-based Fourier Ptychography System**
Discipline	Physics
Supervisor(s)	Dr Cushla McGoverin Prof. Frédérique Vanholsbeeck Supported by Suyash Mehta (PhD candidate)
Contact details	c.mcgoverin@auckland.ac.nz
Skills Needed	• Good organisational skills and attention to detail • Commitment to follow laboratory safety practices and protocols • Experience with MATLAB, Python or similar

Project description

Fourier ptychography microscopy (FPM) is a recently developed super-resolution imaging technique that offers an alternative way to bypass the resolution limit imposed by the numerical aperture (NA) of the objective lens, by creating a synthetic NA. A fundamental FPM configuration captures multiple perspective images of a sample, each corresponding to distinct, small apertures within the Fourier domain. The FPM generates high-resolution images by recording larger scattering angles compared to a standard light field microscope. Unlike light field microscopy, which compromises spatial resolution to capture all perspectives in a single snapshot, FPM acquires each perspective sequentially. Furthermore, it synthesises different angular perspectives to enhance the spatial resolution of a 2D object. Our goal in this project will be to develop and test the FPM system's functionality.

Within this project the student will primarily work on the development of a Fourier Ptychography microscope. The student will be involved with assembling the optical components and control of the microscope. Further, there will be a need to process the data using the FPM algorithm (the algorithm will be provided).

Faculty of Science
Summer Research Scholarships

2026/2027 Projects (Physics)

Project code	SCI082
Project title	**How do Crustaceans Hear?**
Discipline	Physics
Supervisor(s)	Prof. Frédérique Vanholsbeeck Dr Jami Shepherd Craig Radford (PhD candidate) Supported by Tillmann Spellauge (PhD candidate)
Contact details	f.vanholsbeeck@auckland.ac.nz tillmann.spellauge@auckland.ac.nz
Skills Needed	• An interest in using light to study biological samples (biophotonics) • Good organisational skills and attention to detail • Commitment to follow laboratory safety practices and protocols • Experience with MATLAB, Python or similar

Project description

It is well-established that crustaceans are using sound for interspecies communication. However, the mechanism for sound detection is still poorly understood. To fill this research gap, we employ optical coherence tomography-based vibrometry to measure the mechanical response of different organs to acoustic stimuli. We seek help conducting large-scale experiments on snapping shrimp and Aotearoa paddle crabs. During the project, you will gain insights into optical coherence tomography and how to conduct experiments to produce statistically significant results.

Faculty of Science
Summer Research Scholarships

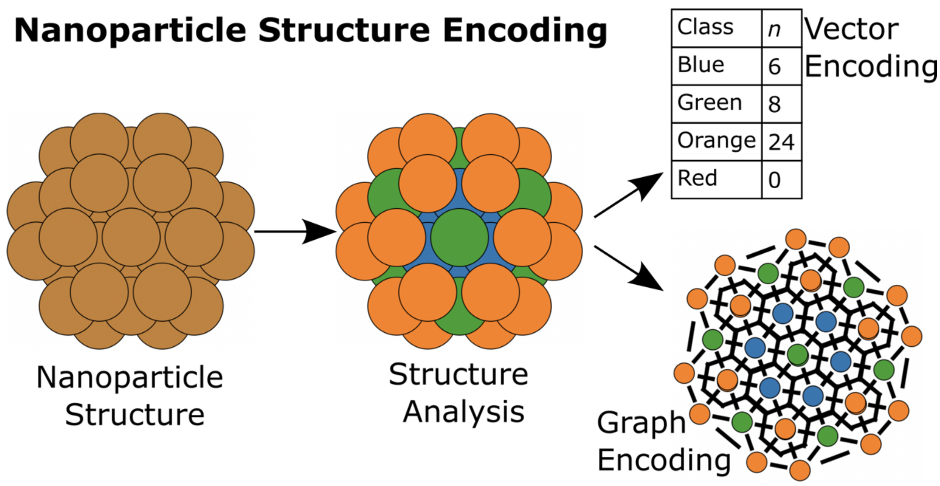
2026/2027 Projects (Physics)

Project code	SCI083
Project title	**Graph Representations for Nanoparticle Structure Prediction**
Discipline	Physics
Supervisor(s)	Dr Nicholas Smith Prof. Nicola Gaston
Contact details	nicholas.smith@auckland.ac.nz
Skills Needed	• Some programming experience, preferably Julia or perhaps Python • Familiarity with a command line interface • Experience with machine learning and/or graphs is a bonus.

Project description

Metallic nanoparticles, consisting of tens to thousands of atoms, have a wide variety of potential applications including medical imaging and energy storage. However, the properties and behaviours of nanoparticles depend heavily upon the atomic arrangements, or shapes, they adopt. The shape of a particular nanoparticle can be predicted computationally by searching for the lowest energy structure (the global minimum) with so-called global optimisation (GO) algorithms. The search space of these algorithms is vast, in excess of 10^{21} structures even for small nanoparticles, yet the algorithm must locate the global minimum within ~10^{6} structure checks to be viable. One GO algorithm, the divide-and-conquer algorithm, uses machine learning to define distinct areas of the search space on-the-fly that are then searched separately, improving the algorithm's efficiency.

This Summer Research project aims to develop, program, and benchmark a new way to encode the nanoparticle structure for the divide-and-conquer algorithm, specifically using graphs (nodes connected by edges) instead of vectors (tables) as shown below. The graphs, which include atom connectivity, should improve the specificity of the division model, enhancing the speed of the search, and fast tracking the discovery of new nanoparticles for a variety of uses.



Faculty of Science
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2026/2027 Projects (Physics)

Project code	SCI084
Project title	**Playing a game of life and death with the Fröhlich polaron: New insights by Quantum Monte Carlo simulations**
Discipline	Physics
Supervisor(s)	Dr Elke Pahl Prof. Joachim Brand (Massey University)
Contact details	Elke.Pahl@auckland.ac.nz
Skills Needed	• Interest in numerical simulations using Julia (no prior knowledge of Julia needed) • Some basic condensed matter physics/quantum mechanics knowledge advantageous • Interest in high-performance computing

Project description

The Fröhlich polaron is a classic model of an electron moving through a solid interacting with lattice vibrations (phonons). Such an electron dressed in a cloud of phonons is behaving like a particle called a polaron. The existence of infinitely many bound excited polaron states has recently been mathematically proven for infinite electron-phonon interaction.

We were able to demonstrate the onset of the first bound excited state in the one-dimensional model for an intermediate coupling with our Quantum Monte Carlo (QMC) code written in the modern programming language Julia. Playing a game of life and death in the space of possible electron-phonon configurations, we were able to find ground and excited states of, in principle infinite-dimensional matrices – randomness allowing for new exciting insights! Further code development enables the quest to find further excited states in 1D and/or excited states in 2D – the latter would open the door for experimental confirmation.

The aim of this project is the study of the onset of the second bound excited state in 1D and/or the appearance of bound states in 2D when cranking up the interaction. This work involves getting acquainted with the QMC code and running simulations on NZ high-performance compute cluster.

Faculty of Science
Summer Research Scholarships

2026/2027 Projects (Physics)

Project code	SCI085
Project title	**Classification of Atomic Cluster Configurations with Persistent-Homology and Machine-Learning Methods**
Discipline	Physics
Supervisor(s)	Dr Elke Pahl With support of Matija Čufar
Contact details	Elke.Pahl@auckland.ac.nz
Skills Needed	• Interest in machine-learning classification and persistent homology • Interest in phase transitions (e.g. melting) • Interest in numerical simulations using Python/Julia (no prior knowledge of Julia needed)

Project description

We can describe phase transitions like melting by exploring the space of possible cluster configurations using Monte Carlo methods. During Monte Carlo simulations, we sample a huge number of configurations in dependence of temperature and applied pressures. A classification of this huge set of configurations in certain classes of solid-state configurations and melted ones opens the possibility to gain detailed insight into solid-solid and solid-liquid transitions that are of great interest in high-pressure physics. Besides this specific application of understanding phase transitions better, cluster classification is an important topic in lots of different fields of material physics.

In this project, we want to introduce methods stemming from computational topology into classification tools already in use. We will focus on persistent homology – a mathematical method used to identify and quantify intrinsic structural features (like connected clusters, loops, and voids) under changing spatial resolution. It allows us to track how these topological features evolve under different size scales and record this in persistent diagrams. These can then be used as features for standard classification and clustering algorithms. We will make use of a Julia code Ripserer.jl written by M. Čufar.

Faculty of Science
Summer Research Scholarships

2026/2027 Projects (Physics)

Project code	SCI086
Project title	**3D Imaging via Computation**
Discipline	Physics
Supervisor(s)	Dr Freddy Lyzwa
Contact details	f.lyzwa@auckland.ac.nz
Skills Needed	• Experience in one (or more) of the following areas: Python/Matlab, Algorithm Design, CAD, Additive Manufacturing

Project description

In this interdisciplinary project, which is interlinked with the aerospace research sector, the student will combine computational imaging approaches with in-house-made "lenses" to design lensless microscopes. They will develop a new algorithm (or adapt our existing one) to achieve 3D image reconstruction, and/or investigate the design & fabrication of smart structures that are not lenses in the traditional way. The student will acquire skills around (non)-linear optics, microscopy and spectroscopy, and will work in our team based at the Photon Factory at University of Auckland. Especially helpful is having a background in physics, computer science, machine-learning and/or software engineering/mechatronics.