2022/23 UQ Summer Research Scholarship Program

Research Projects
offered by the
School of Mathematics and Physics (SMP)

How to apply:

The UQ Summer Research Program is offered by the School of Mathematics and Physics (SMP) and UQ Student Employability Centre during the summer vacation period. Here is a list of the available SMP projects for students undertaking mathematics, statistics and physics. It is open to undergraduate (including Honours) and masters by coursework students.

(1) Browse the list of projects.

(2) Contact the supervisor in the area of your interest, or the contact person listed, to discuss your interest and eligibility to undertake their research project. Gain the research project supervisor's tentative approval and include this with your full UQ Summer Research Program application.

(3) Applications open on Monday,15 August and close by Sunday, 18 September 2022.

IMPORTANT NOTE TO APPLICANTS:

- Check your eligibility for the program.
- Read the Conditions of Participation before applying.
- Late applications will not be accepted.

UQ Summer Research Project Description

Supervisor's name	**Dr Hien Nguyen**
Supervisor's contact details	h.nguyen7@uq.edu.au Room 618 Building 69, St Lucia.
Number of student places available	1
Project title	**Finite sample inference for Markov random fields**
Project duration	10 Weeks
Hours of Engagement	20 hours per week
Delivery Mode	Onsite, ideally, but via Zoom is also possible
Description	Markov random fields (MRFs) constitute a natural characterization of the dependence structures of many spatial data settings. The modelling of MRFs tend to require the hypothesis of some parametric class that specifies the mode of dependence between spatial units and their neighbours. Generally, the parameter that defines the dependence for any particular data set is unknown and requires estimation. A typical method for constructing estimators for MRF parameters is via the maximization of the so-called pseudolikelihood function, which specifies the conditional relationships between spatial units and their neighbours. Using these pseudolikelihood functions and the so-called universal inference framework, we are able to construct E-values (random variables with expectation bounded above by 1), which naturally permits the construction of confidence sets and hypothesis tests for model parameters. This project will involve the construction and application of universal inference objects for MRF models.
Expected outcomes	As part of the project, the scholar will be expected to learn about: - Markov random fields - Pseudolikelihood functions - Optimization theory - Pseudolikelihood ratio test statistics - General hypothesis testing and confidence set construction - E-values and P-values - Universal inference framework The scholar will also be tasked with implementing the developed procedures in the R programming language and will be expected to provide a report and short oral presentation on their work at the conclusion of the project. If the project has made sufficient progress, it is possible that a research publication may result as an outcome.
Suitable for	This project is most suitable for 3rd or 4th year Bachelor of Science/Arts (Mathematics/Statistics Majors) or Bachelor of Mathematics student. The scholar should have a background in - Probability theory - Real analysis - Applied statistics - R programming
Other important details	NA

UQ Summer Research Project Description

Supervisor's name	**Dr Hien Nguyen**
Supervisor's contact details	h.nguyen7@uq.edu.au Room 618 Building 69, St Lucia.
Number of student places available	1
Project title	**Testing for the presence of random effects in a mixed model**
Project duration	10 Weeks
Hours of Engagement	20 hours per week
Delivery Mode	Onsite, ideally, but via Zoom is also possible
Description	Mixed effects models form the basis for many inferential procedures relating to repeated measures and longitudinal regression analyses. A common problem in mixed effects modelling is the decision as to whether a mixed effects model (one with both random and fixed effects) is necessary at all, or whether a simpler fixed effect model will suffice. The natural solution to this problem is to consider a hypothesis test of a fixed effect null versus a mixed effect alternative. Although simple to state, the construction of such a test is made difficult due to the non-standard asymptotics of typical test statistics, under the null hypothesis, due to the fact that the null hypothesis lies of the boundary of the parameter space that characterizes the model. This project considers the use of a recent procedure, known as Universal Inference, which allows for the construct of finite sample tests, via hold-out likelihood ratio test statistics. Such a technique can be used to construct valid tests that does not rely of asymptotics and are thus feasible in the face of boundary problems. The project will investigate the theoretical and practical properties of such tests, and will assess their feasibility via computation and simulation studies in the R programming language.
Expected outcomes	As part of the project, the scholar will be expected to learn about: - Mixed effects models - Likelihood functions - Optimization theory - Likelihood ratio test statistics - General hypothesis testing and confidence set construction - E-values and P-values - Universal inference framework The scholar will also be tasked with implementing the developed procedures in the R programming language and will be expected to provide a report and short oral presentation on their work at the conclusion of the project. If the project has made sufficient progress, it is possible that a research publication may result as an outcome.
Suitable for	This project is most suitable for 3rd or 4th year Bachelor of Science/Arts (Mathematics/Statistics Majors) or Bachelor of Mathematics student. The scholar should have a background in - Probability theory - Real analysis - Applied statistics - R programming
Other important details	NA

UQ Summer Research Project Description

Supervisor's name	**Dr Hien Nguyen**
Supervisor's contact details	h.nguyen7@uq.edu.au Room 618 Building 69, St Lucia.
Number of student places available	1
Project title	**Predicting with confidence via interval estimators and conformal prediction**
Project duration	10 Weeks
Hours of Engagement	20 hours per week
Delivery Mode	Onsite, ideally, but via Zoom is also possible
Description	Regression models are often constructed to generate predictions of future unobserved data. A common practice in predictive inference is to not only generate a future prediction, but also a confidence interval for the future prediction, often called the prediction interval. The construction of valid prediction intervals can often be mathematically complicated. Recently, the method of conformal prediction has become a popular and reliable approach to constructing finite-sample valid prediction intervals for arbitrary regression models, using a hold-out construction, where upon some of the data is taken to build the predictive model, and the other part of the data are taken to calibrate the confidence intervals for the prediction. However, the outcome of such a process does not generally yield an intuitive and visually assessable predictive model outside of regression models with a univariate input. In this project, we consider a triple partitioning hold-out approach to construct predictive intervals. In the first stage, a model is used to predict the phenomenon in question, using all available features as multivariate input. Via the outputted model, an interval estimator is then used to construct univariate prediction intervals, taking univariate input of the initial model predictions. Finally, a conformal prediction step is then used to calibrate the prediction intervals to be correct. This project will investigate the construct of such prediction interval estimators and implement the estimators in the R programming language.
Expected outcomes	As part of the project, the scholar will be expected to learn about: - Regression analysis - Prediction intervals - The hold-out approach - Conformal prediction - Finite sample inference The scholar will also be tasked with implementing the developed procedures in the R programming language and will be expected to provide a report and short oral presentation on their work at the conclusion of the project. If the project has made sufficient progress, it is possible that a research publication may result as an outcome.
Suitable for	This project is most suitable for 3rd or 4th year Bachelor of Science/Arts (Mathematics/Statistics Majors) or Bachelor of Mathematics student. The scholar should have a background in - Probability theory - Real analysis - Applied statistics - R programming
Other important details	NA

UQ Summer Research Project Description

Supervisor's name	**Dr Ramiro Lafuente**
Supervisor's contact details	r.lafuente@uq.edu.au
Number of student places available	1
Project title	**Topics in Riemannian Geometry with symmetries**
Project duration	8-10 weeks
Hours of Engagement	20 hours
Delivery Mode	On site attendance is preferred, however online mode could be accommodated.
Description	The goal of the project is to study important problems about the existence of special Riemannian metrics and the evolution of geometric flows, on spaces with symmetries. The focus will be on some particular but still highly significant case. There is some flexibility regarding the specific problem, this will be adjusted depending on the student's interest.
Expected outcomes	The student will gain experience in dealing with cutting-edge research in pure mathematics. They will learn important techniques for studying geometric flows under symmetry assumptions. There is also the possibility that this might lead to a publication later on.
Suitable for	It is expected that the applicant will be a 3rd or 4th year student with a solid background in Analysis and Differential Geometry. Some knowledge in Lie groups and algebras would be ideal.
Other important details	*The Faculty will advise the students to contact supervisors to gain support for their application, to ensure the student has the appropriate skills and background to undertake the project. Students must upload evidence of supervisors' approval when submitting their application.*

UQ Summer Research Project Description

Supervisor's name	**Dr Mahdi Abolghasemi**
Supervisor's contact details	m.abolghasemi@uq.edu.au
Number of student places available	2
Project title	**Hierarchical time series forecasting**
Project duration	8 weeks
Hours of Engagement	36 hours
Delivery Mode	Remote
Description	Time series forecasting plays a crucial role in many business decision makings. Whether it is sales, temperature, or price, we want to know what will happen in the future and accordingly make decisions today. This project is about forecasting sales time series for a company. Data has hierarchical format, meaning that there is a hierarchical structure in data that needs to be considered. You can search and look at the M5-forecasting competition as an example. In this project, you will use machine learning and statistical models to forecast hierarchical data.
Expected outcomes	You will learn: *Sales forecasting* *Time series forecasting* *There is an opportunity to:* *Present in national or international conferences.* *Writing an article for international journals.* *Collaborate with other researchers in the UK universities.*
Suitable for	Familiar with: statistical models, machine learning Suitable for: Final year undergraduate, Masters/honours students
Other important details	It is not compulsory to know time series, but it would be nice if you are familiar with it. Here is a great reference for hierarchical time series: https://otexts.com/fpp3/hierarchical.html

UQ Summer Research Project Description

Supervisor's name	**Dr Peter Jacobson**
Supervisor's contact details	p.jacobson@uq.edu.au office: 06-436 (Physics Annexe)
Number of student places available	1
Project title	**Superconducting devices by scanning tunnelling microscopy**
Project duration	10 weeks
Hours of Engagement	20-36 hours per week (negotiable)
Delivery Mode	On-site with potential for some remote instrument control
Description	Superconducting circuits are a demonstrated form of quantum technology pursued in academic labs and industry giants such as Google, IBM, IQM and others. However, these devices are not perfect and there is international push to improve device performance. Current devices are limited by the presence of ultrathin (few nm) amorphous oxides at the exposed superconductor surface. In this project, you will use a state-of-the-art ultrahigh vacuum system (UHV) with low-temperature scanning tunnelling microscope (LT-STM) to investigate the atomic scale structure of these oxide layers. Treatments and methods to remove or prevent defects in these oxides will be explored.
Expected outcomes	This is a hands-on experimental project. Participants will use the instrument to prepare samples, acquire data, and perform data analysis. The participant will gain significant knowledge in vacuum technology, condensed matter and surface physics, and image analysis (ImageJ, Gwyddion, or python packages). These skills are currently in demand and widely applicable to the semiconductor and quantum industries.
Suitable for	Participants should have a background in physics and be ready to engage with hands-on work.
Other important details	The goals of this project are connected to an ARC Linkage Project with IQM, Europe's largest quantum computing start up. Honours positions are available to continue the work.

UQ Summer Research Project Description

Supervisor's name	**Professor Warwick Bowen**
Supervisor's contact details	w.bowen@uq.edu.au
Number of student places available	1
Project title	**Field deployment of precision magnetometers for underground communications**
Project duration	10 weeks
Hours of Engagement	36 hours per week
Delivery Mode	This project cannot be completed as remote work
Description	This project will field-deploy precision magnetometers we have developed in underground communications applications. Our magnetometers are a new class of sensor which combines photonics with nanotechnology to achieve very high precision. We are working with the resources company Orica to use them for underground communication. In this project, you would work closely with our partners in Orica to demonstrate the performance of the magnetometers in a real-world setting.
Expected outcomes	This is an opportunity to work to real-world applications of precision technology with a leading Australian company. Within the project you will learn about silicon photonics, precision sensing, and the packaging and integration needed to take these sensors into the field.
Suitable for	This project is only open to third and fourth year students. You should have some prior experience in experimental research. You will need to be highly motivated and committed to work in a team to deliver successful outcomes.
Other important details	*The Faculty will advise the students to contact supervisors to gain support for their application, to ensure the student has the appropriate skills and background to undertake the project. Students must upload evidence of supervisors' approval when submitting their application.*

UQ Summer Research Project Description

Supervisor's name	**Professor Ben Powell**
Supervisor's contact details	powell@physics.uq.edu.au
Number of student places available	2
Project title	**High temperature superconductors by design**
Project duration	6-10 weeks
Hours of Engagement	36 hours per week
Delivery Mode	This project can be completed under a remote working arrangement if necessary.
Description	The theory of high temperature superconductivity (HTSC) is one of the most important unsolved problems in physics. It is clear that if convince the world that you can explain HTSC then you will win a Nobel prize. Yet despite decades of theorists trying, we do not have a comprehensive theory. One problem is that there is so much experimental data for existing HTSCs that it is difficult to make novel predictions against which your theory could be tested. In this project we will work towards a novel solution to this problem. We will take a possible theory of HTSC and use it to design new materials and predict whether they will superconduct.
Expected outcomes	You can expect to learn advanced methods in quantum theory and coding. You will gain experience working with supercomputers. You will be expected to write a report at the end of the project and have the opportunity to turn this report into a peer reviewed scientific publication.
Suitable for	Students should have completed at least 2 years of university with a strong emphasis on physics.
Other important details	*The Faculty will advise the students to contact supervisors to gain support for their application, to ensure the student has the appropriate skills and background to undertake the project. Students must upload evidence of supervisors' approval when submitting their application.*

UQ Summer Research Project Description

Supervisor's name	**Professor Ben Powell**
Supervisor's contact details	powell@physics.uq.edu.au
Number of student places available	2
Project title	**Theory of single molecule switches**
Project duration	6-10 weeks
Hours of Engagement	36 hours per week
Delivery Mode	This project can be completed under a remote working arrangement if necessary.
Description	Switches are fundamental to digital technologies. The most prominent example is the transistor – every phone and computer contains millions of transistors acting as switches. Developing smaller, more efficient switches is vital for future technologies and also to fight global heating (given the enormous energy consumption of current information technologies). A fundamental limit on the size of a switch is the molecular scale. We have recently developed a theory that shows how molecules known as "spin crossover complexes" could be used as switches at room temperature. In this project you will develop the theory to explain how different stimuli (e.g., light and electrical currents) can be used to toggle these switches. This will require developing and solving quantum theories of the molecules with pen and paper, writing code to solve the resulting models and running this code on supercomputers.
Expected outcomes	You can expect to learn advanced methods in quantum theory and coding. You will gain experience working with supercomputers. You will be expected to write a report at the end of the project and have the opportunity to turn this report into a peer reviewed scientific publication.
Suitable for	Students should have completed at least two years of university with a strong emphasis on physics (students focusing on maths or chemistry are also welcome to apply).
Other important details	*The Faculty will advise the students to contact supervisors to gain support for their application, to ensure the student has the appropriate skills and background to undertake the project. Students must upload evidence of supervisors' approval when submitting their application.*

UQ Summer Research Project Description

Supervisor's name	**Dr Ian Marquette, Associate Professor Yao Zhong Zhang and Dr Danilo Latini**
Supervisor's contact details	i.marquette@uq.edu.au, yzz@maths.uq.edu.au , d.latini@uq.edu.au
Number of student places available	1
Project title	**Lotka-Volterra integrable and exactly solvable systems**
Project duration	The length of the project is 10 weeks
Hours of Engagement	36 hours per week
Delivery Mode	The delivery mode is on site, but alternatives are also possible. COVID-19 considerations: Yes, the project can be completed under a remote working arrangement discussed with supervisors.
Description	Lotka-Volterra (LT) systems of differential equations play a role in different areas, and in particular in context of biology in regard of the predator and prey model. However, it is of importance in regard different fields of mathematics, and particularly for the theory of nonlinear differential equations. In general, nonlinear differential equations and systems of nonlinear equations are very difficult to solve, but different ideas can be used to obtain exactly the solution of such equations. In this project we will rely on an algebraic construction to study integrable or even superintegrable deformations of LT systems.
Expected outcomes	The student will be able to understand various ideas on differential equations, integrable models and exactly solvable systems. The student will get further understanding of recently discovered LT systems, or even obtain new deformations of LT systems. The student will be able to gain various skills that have wide applications in different areas of mathematics.
Suitable for	The project is open to applications from students with a background in mathematics or physics, 3rd and 4th year students.
Other important details	*The Faculty will advise the students to contact supervisors to gain support for their application, to ensure the student has the appropriate skills and background to undertake the project. Students must upload evidence of supervisors' approval when submitting their application.*

UQ Summer Research Project Description

Supervisor's name	**Dr Joel Corney**
Supervisor's contact details	j.corney@uq.edu.au Phone: (07) 33653404; Office: 06-434
Number of student places available	1
Project title	**Controlled chaos in ultra cold matter systems**
Project duration	7-8 weeks
Hours of Engagement	30 hours / week
Delivery Mode	On site attendance preferred, but can be done off-site if student has access to appropriate computing software
Description	Utracold atoms in optical lattices provide an elegant, reconfigurable arena for exploring many-body quantum physics in a precisely controlled way. In particular they can be used to probe how the features of dynamical chaos (a classical phenomenon of nonlinear systems) survive in the quantum regime. This project will map out the phase-space of novel lattice systems (with enough degrees of freedom to show chaos in the classical limit, yet small enough such that a quantum description is tractable) and map chaotic features onto the Wigner distribution of the corresponding quantum state.
Expected outcomes	Scholars will further their understanding of dynamical systems (chaos) and how this interfaces with a quantum description, and develop expertise in relevant analytic and computational methods. This project is original research, which could form part of a publication. Scholars will experience what it is like to be part of a research group in theoretical physics, and will be expected to interact with peers and other researchers in the group, including giving a talk on the results of their research.
Suitable for	The project will involve a combination of analytic and computational work. Prior computational experience (in any language) would be an advantage. Some knowledge of quantum mechanics (eg from PHYS2041) and dynamical systems (eg PHYS2100) would be an advantage.
Other important details	*The Faculty will advise the students to contact supervisors to gain support for their application, to ensure the student has the appropriate skills and background to undertake the project. Students must upload evidence of supervisors' approval when submitting their application.*

UQ Summer Research Project Description

Supervisor's name	**Professor Matthew Davis** **Dr Matt Reeves**
Supervisor's contact details	mdavis@physics.uq.edu.au 06-325
Number of student places available	Up to 2
Project title	**Nonequilibrium superfluid flows**
Project duration	6 – 10 weeks depending on availability
Hours of Engagement	20 - 35 hours per week
Delivery Mode	Project can be performed either on campus or remotely. Student should attend relevant research group meetings, either in person or online.
Description	Superfluidity arises when an atomic gas is cooled using laser cooling and evaporative cooling to nanokelvin temperatures. Below a critical velocity they flow without viscosity. The UQ Bose-Einstein condensation laboratory works with these superfluids, and are interested how their nonequilibrium dynamics lead to persistent currents that never decay. The aim of this project is to make a connection between classical mechanics and quantum mechanics - looking for the signatures of classical trajectories in the quantum wave functions. This is potentially interesting for superfluids, as to some extent they behave as classical fluids. This would require adding the effects of particle interactions - an additional nonlinear term in the Schrodinger equation.
Expected outcomes	Students will learn how to solve the linear and nonlinear Schrodinger equation computationally with sources and sinks. The results may influence the UQ experimental program on Bose-Einstein condensates. A successful project will lead to publishing a paper describing the model and its results.
Suitable for	Self-motivated students interested in physics and/or mathematics who are interested in gaining experience in research in theoretical and computational quantum physics.
Other important details	Interested students *must* contact Prof. Davis to discuss their suitability for the project prior to applying. Evidence of supervisor support is required to be uploaded as part of the application process.

UQ Summer Research Project Description

Supervisor's name	**Professor Matthew Davis** **Dr Angela White**
Supervisor's contact details	mdavis@physics.uq.edu.au 06-325
Number of student places available	Up to 2
Project title	**Superfluid point vortex model on a rotating spherical shell**
Project duration	6 – 10 weeks depending on availability
Hours of Engagement	20 - 35 hours per week
Delivery Mode	Project can be performed either on campus or remotely. Student should attend relevant research group meetings, either in person or online.
Description	One of the key characteristics of a superfluid is that they may only rotate by forming quantised vortices. The point vortex model is a simple Hamiltonian system that describes their interactions and dynamics, yet has proven to be surprisingly quantitative in recent experiments performed in the UQ Bose-Einstein condensation laboratory. The aim of this project is to derive the appropriate point vortex model for a two-dimensional superfluid that exists on a spherical shell. This geometry introduces additional topological constraints for the system. The project would be to firstly find the equilibrium states of vortex matter in this system under rotation at zero temperature, and then characterise the thermodynamic equilibrium states and dynamics at finite temperature. An extension of the project would compare the results from the point vortex model to simulations of the Gross-Pitaevskii equation, a more complete model for superfluids.
Expected outcomes	Students will learn how to derive and simulate N-body Hamiltonian systems on a sphere. A successful project will lead to publishing a paper describing the model and its results.
Suitable for	Self-motivated students interested in physics and/or mathematics who are interested in gaining experience in research in theoretical and computational quantum physics.
Other important details	Interested students *must* contact Prof. Davis to discuss their suitability for the project prior to applying. Evidence of supervisor support is required to be uploaded as part of the application process.

UQ Summer Research Project Description

Supervisor's name	**Professor Matthew Davis** **Dr Lewis Williamson**
Supervisor's contact details	mdavis@physics.uq.edu.au 06-325
Number of student places available	Up to 2
Project title	**Model of an atomtronic transistor**
Project duration	6 – 10 weeks depending on availability
Hours of Engagement	20 - 35 hours per week
Delivery Mode	Project can be performed either on campus or remotely. Student should attend relevant research group meetings, either in person or online.
Description	The term "atomtronics" has been coined to describe the creation of electronic circuit-like experiments using ultracold quantum gases. This project will develop a simple model of an atomtronic transistor based on kinetic theory of gases and apply it to understand an experiment performed at the University of Colorado, Boulder. Students will use knowledge of statistical mechanics and thermodynamics to develop a model of particle and energy flow in a three-terminal trap.
Expected outcomes	Students will derive a kinetic model of particle and energy flow building on their knowledge of statistics physics. The model will validate or falsify the understanding described in the experimental paper. A successful project will lead to publishing a paper describing the model and its results.
Suitable for	Self-motivated students interested in physics and/or mathematics who are interested in gaining experience in research in theoretical and computational quantum physics.
Other important details	Interested students *must* contact Prof. Davis to discuss their suitability for the project prior to applying. Evidence of supervisor support is required to be uploaded as part of the application process.

UQ Summer Research Project Description

Supervisor's name	**Professor Matthew Davis**
Supervisor's contact details	mdavis@physics.uq.edu.au 06-325
Number of student places available	Up to 2
Project title	**Dark soliton formation in superfluids from the scattering of sound**
Project duration	6 – 10 weeks depending on availability
Hours of Engagement	20 - 35 hours per week
Delivery Mode	Project can be performed either on campus or remotely. Student should attend relevant research group meetings, either in person or online.
Description	One of the key insights of Landau was to derive a phenomenological formula for the critical velocity in a superfluid. In a Bose-Einstein condensate this is connected to the speed of sound. In a one-dimensional superfluid in a ring, an obstacle moving with a speed of less than the critical velocity can pass through the system without viscosity, i.e. it doesn't create any excitations. If this is accelerated above the critical velocity it will then create topological objects known as dark solitons. This project will study a superfluid ring in which there is an obstacle moving at a speed less than the critical velocity. We will simulate the launching of pulses of sound at the obstacle, and characterise how they scatter from the obstacle as a function of amplitude and obstacle velocity. There will be a transition point at which dark solitons will be formed in inelastic scattering events. The goal of the project is to explain this with reference to Landau's theory of superfluidity. This project can be extended to 2D systems where there will be vortex pair formation.
Expected outcomes	The student will learn how to apply computational methods to solve the nonlinear Schrodinger equation. A complete set of results with appropriate interpretation could be turned into a publication.
Suitable for	Self-motivated students interested in physics and/or mathematics who are interested in gaining experience in research in theoretical and computational quantum physics.
Other important details	Interested students *must* contact Prof. Davis to discuss their suitability for the project prior to applying. Evidence of supervisor support is required to be uploaded as part of the application process.

UQ Summer Research Project Description

Supervisor's name	**Professor Halina Rubinsztein-Dunlop and Dr Alex Stilgoe**
Supervisor's contact details	halina@physics.uq.edu.au; Office: 06-321 stilgoe@physics.uq.edu.au; Office: 06-430
Number of student places available	1
Project title	**Study of coagulation of droplets using optical tweezers**
Project duration	10 weeks
Hours of Engagement	36 hours/week
Delivery Mode	Project will be completed through on-site attendance at St Lucia campus. In case of Lock down a part of the project can be completed remotely. In that case the computational modelling will be conducted. The computational component will be part of the project.
Description	This project is concerned with studies of how oil droplets in an oil-water emulsion deform when trapped and manipulated by multiple optical traps. The particular aspect that we want to study is the coagulation of the droplets. We want to characterise this process using measurements done with Optical Tweezers. The project will involve the use of a recipe to produce emulsion droplets with a low surface tension and deforming them using optical tweezers and bringing two of the droplets together to analyse the coagulation process. Furthermore, measuring the force involved in this process will aid in the understanding of emulsions and their stabilizing process.
Expected outcomes	The students will gain skills in laboratory work concerning optics and understanding of laser micromanipulation process and techniques used in this field. The results of the work could lead to publication giving the student opportunity to generate a publication. The summer student will be a member of a research group, where she/he will be able to present her/his work to the other members of the Optical Micromanipulation Group and also discuss and familiarise themselves with other projects within this group.
Suitable for	This project is open to students from 1st to 3rd year of studies.
Other important details	Interested students *must* contact the supervisor/s, prior to submitting an application. Evidence of supervisor support is required to be uploaded as part of the application process.

UQ Summer Research Project Description

Supervisor's name	**Professor Diane Donovan and Dr James Lefevre**
Supervisor's contact details	dmd@maths.uq.edu.au Office: 67-653 j.lefevre@uq.edu.au Office: 69-705
Number of student places available	1
Project title	**Mathematical techniques in genetics modelling**
Project duration	10 weeks
Hours of Engagement	25 hours/week
Delivery Mode	The project can be completed by attending weekly research meetings in person or via Zoom links with the remainder of the work executed remotely.
Description	There is significant interest in applying mathematical techniques to the modelling of genetic's data. This includes modelling interactions within the data using relationship networks and/or by using ODEs to describe trends in the data. Recent advances in these areas are centred on increasing the complexity of the networks or models to encapsulate more features exhibited in the data. An important part of this research is to test these approaches on data sets that have been studied in the past and to compare and contrast results with previous studies. The aim of this project is to identify, retrieve and study of public data sets in the context of plant genetics as a platform for improving a scholar's data analysis skill and use both the data sets and the skills to test new theories.
Expected outcomes	This project is designed to advance the scholar's knowledge in areas such as graph theory and mathematical modelling and to introduce the scholar to important areas of application. The skills gained in this project will be of use across a broad area of mathematics and biology and of value in future studies. The scholars will also be given the opportunity to work in multidisciplinary team including plant geneticist from around Australia. This work has the potential to lead to co-authorship on research publications.
Suitable for	It is expected that interested scholars will have strong mathematical background and a strong grasp of some high level programming language such as R or Python or MATLAB, with demonstratable experience in these languages. An understanding of graph theory and/or mathematical modelling would be useful.
Other important details	

UQ Summer Research Project Description

Supervisor's name	**Dr Lewis Williamson and Professor Matthew Davis**
Supervisor's contact details	lewis.williamson@uq.edu.au, Office: 06-418
Number of student places available	2
Project title	**Modelling dynamics and thermodynamics of many-body quantum systems**
Project duration	10 weeks
Hours of Engagement	Approximately 30hrs/week
Delivery Mode	Remote or on-site
Description	There are two projects available modelling many-body quantum systems. 1) **Vortex dynamics in spinor Bose-Einstein condensates.** A Bose-Einstein condensate (BEC) is a fluid-like phase of matter that emerges it extremely low temperatures. Stirring a BEC results in the formation of vortices. While quite a lot is known about vortex dynamics in single-component BECs, much less is known about vortex dynamics in multi-component (spinor) BECs. This project will explore the unique properties of vortices in spinor BECs, studying the effects of magnetic fields on the dynamics. 2) **Quantum heat engines.** This project will devise an engine cycle and explore the effect of coherence and entanglement on engine performance in one of the following systems: - Two atoms in an optical tweezer, studying the effects of particle statistics (boson/fermion) and interactions on engine performance - An optomechanical resonator, using open quantum systems - Coupled atoms in a cavity, using open quantum systems
Expected outcomes	The student will gain insights into numerical and analytic methods to model the dynamics of many-body quantum systems. The student will have the opportunity to attend and present at journal clubs and group seminars, gaining exposure to the wide variety of many-body quantum physics occurring at UQ. The student will be expected to present a summary of their findings at the end of the project, either as an oral presentation or as a written report.
Suitable for	This project is suitable for students with a strong physics background ($3^{rd}/4^{th}$ year or very capable $1^{st}/2^{nd}$ year students). Familiarity with Matlab or other numerical modelling software will be useful but not essential.
Other important details	For more details feel free to email me and we can arrange a meeting.

UQ Summer Research Project Description

Supervisor's name	**Dr Duy-Minh Dang**
Supervisor's contact details	duyminh.dang@uq.edu.au Office: 67-744
Number of student places available	2
Project title	**A study of Neural Network methods for solving stochastic control problems in finance**
Project duration	10 weeks long
Hours of Engagement	30 hours/week
Delivery Mode	Onsite attendance is preferred. Remote working will be considered on a case-by-case basis.
Description	The project aims at studying applications Neural Networks (NNs) to solve high-dimensional non-linear Partial Differential Equations (PDEs) arising from stochastic control problems in finance.
Expected outcomes	An understanding of how to design, build and train suitable Neural Networks for PDE formulations of problems arising in finance. It is expected that students will (i) produce a technical report, which could become parts of a research paper, and (ii) deliver an oral presentation.
Suitable for	This project is open to applications from 3-4 year or Honour/Master students with a sufficiently strong background in stochastic processes (Ito calculus, stochastic differential equations) and partial differential equations. Some prior knowledge in machine learning techniques, such as neural networks, are highly desirable. Strong programming skills (in Python, TensorFlow) and familiarities with basic financial concepts/products are preferred.
Other important details	Interested students must contact the supervisor prior to applying. Successful application must include document indicating the supervisor's support.

UQ Summer Research Project Description

Supervisor's name	**Dr Xin Guo**
Supervisor's contact details	Email: xin.guo@uq.edu.au Office: Priestley Building (67), Room 447; Telephone: +61 7 3346 9728
Number of student places available	1
Project title	**Deep Learning Classification with Imbalanced Data**
Project duration	10 Weeks
Hours of Engagement	28 hours per week
Delivery Mode	The project can be completed under a remote working arrangement. On-site attendance is not required. However, occasional on-site meetings is very important.
Description	In recent years deep learning has been developed to be a powerful machine learning methodology for complicated prediction tasks. In practice, mature deep learning platforms are well developed and are very easy to use. In theory, extensive research has been done on the approximation capacity of deep neural networks with fully connected layers and special structures. One of the most important application scenarios of machine learning is classification, where a function is trained with data, to predict the classification labels (e.g., 0/1 for two-class classification problems, or 1,2,...,n for multi-class classification problems) for new observations. It is not uncommon that for some problems, the training data class proportions are highly skewed (for example, one has many more negative cases than positive cases, in a rare cancer screening exercise). This kind of data is usually referred to as imbalanced data. In this project, we plan to study, both empirically and theoretically, the performance of some specially designed deep learning algorithms on learning with imbalanced data.
Expected outcomes	The expected outcomes of this project include: 1. Scholars can learn the popular approaches on mathematical analysis of the capacity of deep neural networks. 2. Scholars can learn the AUC maximization approach for learning with imbalanced data. 3. Scholars can learn the implementation of deep learning on the python platform.
Suitable for	This project is open to applications from students with a solid background in mathematics, or 3rd and 4th year students only.
Other important details	*The Faculty will advise the students to contact supervisors to gain support for their application, to ensure the student has the appropriate skills and background to undertake the project. Students must upload evidence of supervisors' approval when submitting their application.*

UQ Summer Research Project Description

Supervisor's name	**Dr Charles Woffinden**
Supervisor's contact details	Email: c.woffinden@uq.edu.au Telephone: 0423972884
Number of student places available	2
Project title	**Stabilising optical lattices for Bose-Einstein condensates**
Project duration	10 weeks
Hours of Engagement	36 hours per week
Delivery Mode	Internal - this project is primarily experimental, and will be conducted in the UQ Bose-Einstein Condensation Lab.
Description	Ultracold atoms are trapped in magnetic and optical traps. Trapping of ultracold atoms and condensing them into a Bose-Einstein condensate (BEC) allows us to study many quantum mechanical phenomena, such as the superfluid fountain effect and clustering of quantum vortices, leading to local negative absolute zero temperatures. One method to optically trap ultracold atoms is in an optical lattice: Through interference of two optical beams, we create an accordion-shaped set of fringes in which we trap our atoms. While this method allows us to create very pure BECs, the downside of using optical interference is that it is very susceptible to phase fluctuations of the laser beams, mainly induced through vibrations. These vibrations shake the atoms inside the lattice heating them and reducing the lifetime of the BEC. The aim of this project is to design and test a feedback system that is robust against any mechanical noise. The project includes a literature review of successful feedback schemes for optical lattices, programming a microcontroller to realise a feedback system, and setting up a proof-of-principle stabilized optical lattice in our lab.
Expected outcomes	Experience with aligning of optics for a high-precision experiments, programming experience, understanding of the physics of trapping ultracold atoms.
Suitable for	Some coding knowledge would be useful but not strictly required. This project is suitable for 2nd or 3rd year students that are interested in obtaining hands on experience in research labs.
Other important details	Interested students must contact the supervisor, prior to submitting an application. Evidence of supervisor support is required to be uploaded as part of the application process.

UQ Summer Research Project Description

Supervisor's name	**Dr Charles Woffinden**
Supervisor's contact details	Email: c.woffinden@uq.edu.au Telephone: 0423972884
Number of student places available	1
Project title	**Autofocusing of Sculpted Light Potentials for Bose Einstein Condensate Experiments**
Project duration	10 weeks
Hours of Engagement	36 hours per week
Delivery Mode	This project will involve a mixture of hands-on lab work and computer-based activities.
Description	Bose Einstein condensates (BECs) are used to study quantum effects at the macroscopic scale. This has allowed BEC systems to be developed into quantum simulators and extremely sensitive sensors for applications like the search for dark matter. To do this, it is necessary to have a very high level of control over the parameter space of the atoms involved. In the UQ BEC lab, we achieve this control by projecting arbitrary light patterns onto the condensates and have managed to create optical potentials which trap the atoms with resolutions of about 1 µm (close to the diffraction limit of the light used). This does however mean that we are very susceptible to small changes in environmental conditions, leading to a lot of time being spent focussing optics to maintain this resolution. The project aims to improve this process by implementing autofocusing of lenses that project these light potentials using computer interfaced lens stages. It will involve implementing the pre-existing software to control these lenses, developing a way of determining when optimal focusing has been achieved and then feeding back to alter the lens position.
Expected outcomes	Experience with aligning of optics for a high-precision experiment, experience in programming feedback systems, understanding of the physics of trapping ultracold atoms. Implementation of an optical autofocusing system. Experience in image processing.
Suitable for	Some basic experience in coding is useful. This project is suitable for 2nd or 3rd year students that are interested in obtaining experience in research labs.
Other important details	Interested students must contact the supervisor, prior to submitting an application. Evidence of supervisor support is required to be uploaded as part of the application process.

UQ Summer Research Project Description

Supervisor's name	**Dr Tyler Neely**
Supervisor's contact details	Email: t.neely@uq.edu.au Telephone: 0431 999 606 Office: Physics Annexe Building 6, Room 326
Number of student places available	2
Project title	**Quantised vortex cluster detection in Bose-Einstein condensates through machine learner image processing**
Project duration	10 weeks
Hours of Engagement	36 hours per week
Delivery Mode	This project will require some computational work building up to direct involvement in the laboratory.
Description	Bose-Einstein condensates (BECs) are an example of a superfluid system, described by a macroscopic wavefunction. The bulk of the superfluid is irrotational (zero circulation) and only poles in the wavefunction can support quantised amounts of circulation. These poles are referred to as quantised vortices and are of interest when studying quantum turbulence in BEC superfluids. One difficult task when analysing these vortices is defining clustering in an objective manner. Cluster sorting can be considered a subset of the tasks appropriate for machine learning algorithms to solve. In addition, the experimental results available to us are images. Therefore, image processing is also required which is another task suitable for machine learners. The aim of the project is to develop a complete machine learning algorithm to detect and graphically map quantised vortex clusters from single-shot images taken in the experiment. To accompany this, the algorithm will need to be error-tested using simulations of the system. Some research into the most appropriate algorithm will also be required.
Expected outcomes	Experience in programming simulations, experience in interfacing multiple programs to operate simultaneously, experience in various machine learning algorithms, development of understanding of BECs and related experiments, hands-on experience incorporating developed programs into existing experimental apparatus.
Suitable for	Some experience in coding is useful. This project is suitable for 2nd or 3rd year students that are interested in obtaining experience in research labs. Also suitable for students interested in machine learning.
Other important details	Interested students must contact the supervisor, prior to submitting an application. Evidence of supervisor support is required to be uploaded as part of the application process.

UQ Summer Research Project Description

Supervisor's name	**Dr Tyler Neely**
Supervisor's contact details	t.neely@uq.edu.au Telephone: 0431 999 606 Office: Physics Annexe Building 6, Room 326
Number of student places available	1
Project title	**Generating and trapping vortices in a Bose-Einstein condensate**
Project duration	10 weeks
Hours of Engagement	36 hours per week
Delivery Mode	This project will mainly involve experimental work on the UQ BEC apparatus so will require in-person participation. Parts of the project will involve developing Matlab routines and can be completed remotely.
Description	The UQ Bose-Einstein condensation lab has highly developed methods for producing thin films of atomic superfluid and trapping and manipulating them using optical tweezers. The aim of this project is to investigate quantum vortices in the superfluid, which are like tiny whirlpools broadly similar to classical systems but possessing quantised angular momentum. Building on recent successes in experimentally producing and measuring these vortices at UQ (https://arxiv.org/abs/2010.10049), this project aims to experimentally investigate the results of other UQ research that theoretically looked at the dynamics of pinning vortices in the BEC (https://arxiv.org/abs/2102.04712). Quantised vortices can be pinned (have their position fixed in place) by producing a density dip in the superfluid. This theory paper investigated the strength and dynamics of pinning, depending on the depth of the density dip. This summer project will aim to investigate a proof of principle experiment, where the depth of a pinning potential will be modified and the relative velocity of the barrier required for depinning determined. The project will involve developing a control sequence for the optical trap for the BEC, based on existing software. The aim will then be to experimentally pin vortices and then determinine the barrier velocity required for unpinning.
Expected outcomes	Understanding of the physics of trapping ultracold atoms, understanding vortex generation in superfluids, Matlab programming experience, general optical/experimental physics lab experience.
Suitable for	Some coding knowledge would be useful but not strictly required. This project is suitable for 2nd or 3rd year students that are interested in obtaining hands on experience in research labs.
Other important details	Interested students must contact the supervisor prior to submitting an application. Evidence of supervisor support is required to be uploaded as part of the application process.

UQ Summer Research Project Description

Supervisor's name	**Dr Matthew Edmonds**
Supervisor's contact details	m.edmonds@uq.edu.au
Number of student places available	1
Project title	**Quantum droplet dynamics in atomic superfluids**
Project duration	6-10 weeks
Hours of Engagement	Students researchers would be expected to engage in their project for around 20-36hrs/wk. This is flexible depending on the students other academic commitments and University holidays.
Delivery Mode	If required guidance via video conferencing can be provided, otherwise face-to-face support will be given during the project.
Description	Over the last few years there has been a tremendous amount of excitement surrounding the experimental generation of so-called quantum droplets, an unusual state of matter where weakly interacting atomic gases behave like liquids, showing effects such as surface tension. These states of matter have been realised in gases of magnetic as well as two-component (binary) quantum gas systems. Such states provide an important tool for future in applications in metrology, atomtronics and also for understanding the fundamentals of atomic systems. Although quantum droplets can be stable in three-dimensions, it is interesting to try to understand their existence and properties in lower dimensions. As such we would investigate the behaviour of single and also pairs of droplets held in a one-dimensional trapping potential, with the goal of understanding how their collisions can be detected in experiments.
Expected outcomes	Scholars will learn how to solve the nonlinear Schrödinger equation, its basic (soliton) solutions as well as the quantum droplet, and how these are related. Depending on the student's interest; the project can either be analytical or have a numerical component, in which case simulations of the droplet will be performed using for example Matlab or Python. There are opportunities to lean new problem-solving skills related to a real research problem as well as developing numerical skills that would be beneficial to their future studies.
Suitable for	This project would suit Bachelor (honours) and master students interested in analytical and/or numerical calculations, either in their 2nd or 3rd year.
Other important details	*The Faculty will advise the students to contact supervisors to gain support for their application, to ensure the student has the appropriate skills and background to undertake the project. Students must upload evidence of supervisors' approval when submitting their application.*

UQ Summer Research Project Description

Supervisor's name	**Dr Guillaume Gauthier**
Supervisor's contact details	Email: g.gauthier@uq.edu.au Phone: 0435455384
Number of student places available	1
Project title	**Manipulation and Measurement of a Bose-Einstein Condensate**
Project duration	10 weeks: 28 November – 3 February (Flexible)
Hours of Engagement	36 hours per week
Delivery Mode	On campus but some aspects of the project can be performed remotely. Student should attend research group meetings.
Description	What is a BEC? Turns out that at really-low temperatures cold atoms have very-weird behaviours they start behaving more like waves and less like the billiard balls that we know and love. This in turn lets them express their quantum nature more strongly making cold temperature regimes a breeding ground for quantum phenomenon and the perfect environment to study them. Solids, liquid, gas, plasmas, are known to most but at really low temperature a new exotic state of matter emerges: the Bose-Einstein condensate where all the atoms occupy the same state and behave like a macroscopic quantum wave. It has weird properties chief among them being irrotationality and frictionless like superfluids with phase coherent like a laser but is made up of atoms instead of photons. This allows for the investigation of quantum effects at a macroscopic level! The Bose-Einstein Condensate (BEC) Laboratory at UQ uses lasers and magnetic traps to contain and cool atoms down to the Bose-Einstein condensate state of matter. We explore problems of fundamental physics such as investigating turbulence in superfluids and quasi-particle systems in negative absolute temperature regimes and their consequence for underlying host physical systems. We produce emulations of other quantum and classical systems, such as pulsar glitches and the big red spot on Jupiter, and perform precision sensing, focusing on the measurement of rotation and magnetometry. We are currently in the mist of setting up a new functionality for our experiments to increase the range of systems we can simulate and physics we can explore. We are therefore open to any student interested in a project dedicated to learning, developing and implementing new techniques to control and measure of cold atom systems.
Expected outcomes	The student will gain a better understanding of atomic and superfluid physics; as well as, get first-hand experience with actual experimental techniques used in most physics experimental lab.
Suitable for	Physics/engineering students who are interested in pursuing an experimental project in a state-of-the-art quantum physics lab. Experience with electronics, programming (any language), and data processing is a plus.
Other important details	The project can be tailored to have components of measurements, design and simulation depending on candidate preferences and qualification. Please contact Dr Guillaume Gauthier by e-mail (g.gauthier@uq.edu.au) if you are interested prior to applying. Interested students must contact the supervisor, prior to submitting an application. Evidence of supervisor support is required to be uploaded as part of the application process.

UQ Summer Research Project Description

Supervisor's name	**Dr Guillaume Gauthier**
Supervisor's contact details	Email : g.gauthier@uq.edu.au Phone: 0435455384
Number of student places available	1
Project title	**Engineering Dispersion Relation in Superfluid Phononic Waveguides**
Project duration	10 weeks: 28 November – 3 February (Flexible)
Hours of Engagement	36hrs per week
Delivery Mode	On campus preferred but can also be performed remotely. Student should attend research group meetings. Although this project is primarily theoretical, regular interactions with the experimental group and collaborators will be expected, with optional desk space provided in the experimental lab's control room.
Description	Phonons propagating in a uniform medium tend to have a linear dispersion relationship, which means the speed at which the phonons propagate is independent of wavelength and the energy of the phonons is directly proportional to their frequency. While this is useful and desirable when transmitting phonon wave packets over long distances, it can be detrimental to proposed applications of standing wave phonons, such as in phononic waveguides for measuring rotation that require long phonon lifetimes. Even at absolute zero temperature, the linear dispersion of phonons means there are many scattering channels, limiting the usefulness of these architectures. In acoustic circuits this limitation can be overcome by engineering the dispersion relationship to be nonlinear in the system/waveguide through elements such as filters, which limit the scattering channels into which the phonons can decay, and greatly increase the standing wave lifetime. We are looking for a student to simulate the implementation of such classical phononic band-pass filters in a superfluid system, hopefully demonstrate a significant improvement in the lifetime of phononic standing waves over linear waveguides. If successful, these results will lead to experiments in the UQ Bose-Einstein condensation laboratory which could be a follow up/honours for the student.
Expected outcomes	The student will learn how to apply computational methods to solve the nonlinear Schrodinger equation. A complete set of results with appropriate interpretation could be turned into a publication.
Suitable for	Some basic coding experience is desirable, but not required. This project is more suitable to 2nd or 3rd year students.
Other important details	Please contact Dr Guillaume Gauthier by e-mail (g.gauthier@uq.edu.au) if you are interested prior to applying. Interested students must contact the supervisor, prior to submitting an application. Evidence of supervisor support is required to be uploaded as part of the application process.

UQ Summer Research Project Description

Supervisor's name	**Professor Halina Rubinsztein-Dunlop and Dr Alex Stilgoe**
Supervisor's contact details	Email : halina@physics.uq.edu.au; Office: 06-321 Email : stilgoe@physics.uq.edu.au; Office: 06-430
Number of student places available	1
Project title	**Temperature dependence in rotating optical tweezers**
Project duration	10 weeks
Hours of Engagement	36 hours/week
Delivery Mode	Project will be completed through on-site attendance at St Lucia campus. In case of lock down a part of the project can be completed remotely. In that case the computational modelling will be conducted.
Description	Optical Tweezers enable three dimensional trapping and manipulation of small object through transfer of optical momentum. This manipulation has become a very powerful tool with wide applications in physics as well as in complex biological systems. Spin angular momentum can also be transferred to the trapped birefringent particles setting them into rotation. That enables even broader use of this technique in many exciting fields. To record useful and accurate measurements of living biological specimens with Optical Tweezers, it is important to precisely control the temperature of the sample to reflect in vivo environmental conditions. It is also vital for microrheological studies of complex fluids as their viscoelastic properties are temperature dependent. This project aims to design, implement, and characterise a heating element to an optical tweezers apparatus. In particular, this will be incorporated for Rotational Optical Tweezers experiments, where a birefringent microsphere can be optically trapped and rotated using polarised light, enabling microrheometry and torque measurements.
Expected outcomes	The students will gain skills in laboratory work concerning optics and understanding of laser micromanipulation process and techniques used in this field. The summer student will a member of a research group, where she/he will be able to present her/his work to the other members of the Optical Micromanipulation Group and also discuss and familiarise themselves with other projects within this group.
Suitable for	This project is open to students from 1st to 3rd year of studies.
Other important details	Interested students must contact the supervisor/s, prior to submitting an application. Evidence of supervisor support is required to be uploaded as part of the application process.

UQ Summer Research Project Description

Supervisor's name	**Dr Andrew Groszek** **Professor Matthew Davis**
Supervisor's contact details	a.groszek@uq.edu.au 06-418
Number of student places available	Up to 2
Project title	**Rotation sensing using a ring-shaped superfluid**
Project duration	6 – 10 weeks depending on availability
Hours of Engagement	20 - 35 hours per week.
Delivery Mode	Project can be performed either on campus or remotely. Student should attend relevant research group meetings, either in person or online.
Description	The Bose-Einstein condensation laboratory at UQ has recently demonstrated that a ring-shaped superfluid can be used as a rotation sensing device. The experimental scheme involves exciting standing waves in the superfluid density and observing their rotation. As a result, the precision of the device is limited by the lifetime of these density waves. This project will consider variations on the ring-shaped geometry that may extend the lifetime of the excitations and improve the precision of the rotation sensor.
Expected outcomes	Students will learn how to numerically simulate the nonlinear Schrodinger equation. The results may influence the UQ experimental program on Bose-Einstein condensates. A successful project will lead to publishing a paper describing the model and its results.
Suitable for	Self-motivated students interested in physics and/or mathematics who are interested in gaining experience in research in theoretical and computational quantum physics.
Other important details	Interested students *must* contact Prof. Davis to discuss their suitability for the project prior to applying. Evidence of supervisor support is required to be uploaded as part of the application process.

UQ Summer Research Project Description

Supervisor's name	**Dr Andrew Groszek** **Professor Matthew Davis**
Supervisor's contact details	a.groszek@uq.edu.au 06-418
Number of student places available	Up to 2
Project title	**Superfluid vortex dynamics in angular geometries**
Project duration	6 – 10 weeks depending on availability
Hours of Engagement	20 - 35 hours per week.
Delivery Mode	Project can be performed either on campus or remotely. Student should attend relevant research group meetings, either in person or online.
Description	One of the key characteristics of a superfluid is that it may only rotate by forming quantised vortices. For the past two decades, many experiments have explored the behaviour of these quantised vortices, for example in large vortex lattice configurations, or in configurations of just one or two vortices. However, only recently have experimental advances allowed for superfluids to be created in non-circular containers, raising the question of how the vortex dynamics are altered by the shape of the boundaries. This project will consider the dynamics of vortices in angular geometries (for example, triangular or square walls), where the sharp boundaries may give rise to novel behaviour. The project has scope to explore a variety of different configurations and behaviours.
Expected outcomes	Students will learn how to solve the nonlinear Schrodinger equation in two dimensions, and/or how to derive and simulate N-body Hamiltonian systems with nontrivial boundary conditions. A successful project will lead to publishing a paper describing the model and its results.
Suitable for	Self-motivated students interested in physics and/or mathematics who are interested in gaining experience in research in theoretical and computational quantum physics.
Other important details	Interested students *must* contact Prof. Davis to discuss their suitability for the project prior to applying. Evidence of supervisor support is required to be uploaded as part of the application process.

UQ Summer Research Project Description

Supervisor's name	**Dietmar Oelz**
Supervisor's contact details	d.oelz@uq.edu.au, 69-710
Number of student places available	1
Project title	**Statistical analysis of syntaxin1a and Munc18-1 hotspotting in the plasma membrane of neurosecretoy cells**
Project duration	8-10 weeks
Hours of Engagement	20-36 hours per week
Delivery Mode	Either Zoom or in-person meetings, though I usually prefer in-person meetings since they are far more effective.
Description	Super resolution microscopy (by the group of F. Meunier (QBI)) reveals locally recurrent transient clustering of active site proteins. Our goal is develop a statistical test to provide evidence for repeated switching on, off and on again in order to provide evidence for the presence of temporarily active scaffold structures which can not be observed in the microscope.
Expected outcomes	In collaboration with myself and Hien Duy Nguyen (SMP) you'll develop skills in data science, statistic analysis and scientific writing.
Suitable for	This project is open to applications from students with a background in statistics and knowledge in programming (data science).
Other important details	*The Faculty will advise the students to contact supervisors to gain support for their application, to ensure the student has the appropriate skills and background to undertake the project. Students must upload evidence of supervisors' approval when submitting their application.*

UQ Summer Research Project Description

Supervisor's name	**Dietmar Oelz**
Supervisor's contact details	d.oelz@uq.edu.au, 69-710
Number of student places available	1
Project title	**Mathematical modelling and simulation of stress fibres in living cells**
Project duration	8-10 weeks
Hours of Engagement	20-36 hours per week
Delivery Mode	Either Zoom or in-person meetings, though I usually prefer in-person meetings since they are far more effective.
Description	Stress fibres are contractile bundles of actin filaments and associated proteins in living cells. They generate tension providing the mechanical backbone of cells such as fibroblasts. In this project we are interested in understanding how the internal structure of stress fibres changes in time giving rise to tension and contraction. Note that within stress fibres these structures are highly packed and cannot be tracked using microscopy. Therefore we use modelling and simulation to gain insight.
Expected outcomes	The Scholar will develop skills in mathematical modelling and simulation. Depending on your interests and project status, we will formulate and simulate particle models for actin filaments and motor proteins based on an ongoing honours project, and/or we derive and simulate continuum models. An important goal is to study model predictions numerically and compare with experimental observations.
Suitable for	This project is open to applications from students with a background in mathematical modelling, differential equations and programming.
Other important details	*The Faculty will advise the students to contact supervisors to gain support for their application, to ensure the student has the appropriate skills and background to undertake the project. Students must upload evidence of supervisors' approval when submitting their application.*