2018 SMP Vacation Research Scholarship Program

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

This document provides a list of available projects of interest to 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.
3. Gain the research project supervisor's tentative approval, and include this with your full SMP Vacation Research Program application.
4. Submit your application via StudentHub.

SMP Vacation Research Scholarship 2018 / 2019

Supervisor's name	Professor Dirk P. Kroese
Supervisor's contact details	kroese@maths.uq.edu.au https://people.smp.uq.edu.au/DirkKroese/
Number of student places available	4
Project title ***SMP-18-VRP01***	Mathematical and Statistical Methods for Data Science and Machine Learning
Project description	I am currently writing a book with the same title as above, due for publication in July 2019. You will get the latest version of the book, and will help to "test-drive" the book. This could mean, carefully proofreading various sections, trying the exercises, testing the programs, checking links, finding new data sets, etc. The book will have around 500 pages and discusses topics such as supervised and unsupervised learning, Monte Carlo methods, regression, classification, support vector machines, kernels, tree methods, and deep learning. It requires background knowledge in linear algebra, functional analysis, optimization, and probability and statistics. This background knowledge is given in the appendices (as well as primers on Matlab and Python). We will work from a shared dropbox directory, and have regular meetings (say two per week) to monitor your progress.
Project duration	1 December – 30 January with break (8 weeks total).
Expected outcomes	Better understanding of the mathematical and statistical methods that underpin the algorithms in modern data science and machine learning. Improved skills in programming (Python, Matlab) and mathematical writing (LaTeX).
Suitable for	Students with excellent knowledge of 3rd-year mathematics, probability, and statistics. Students with a grade of 7 for STAT3004 or STAT3001 are given preference.
Other important details (if applicable)	During the winter break I have had a group of mostly 2nd year students on a similar project, which proved very successful for everyone involved. This time I would like to go a bit further and ask assistance of students who have enough experience to go deeper into the theory.

SMP Vacation Research Scholarship 2018 / 2019

Supervisor's name	Dr Masoud Kamgarpour
Supervisor's contact details	Masoud@uq.edu.au
Number of student places available	1
Project title *SMP-18-VRP02*	Character variety for symplectic groups
Project description	Understanding the geometry and topology of the character varieties associated to Riemann surfaces has been an active area of research in the past decade. A novel breakthrough of Hausel and Rodriguez-Villegas was to use point counting over finite fields and the Weil conjectures, to obtain information about the geometry. They considered only the case of G=GL_n. The goal of this project is to investigate the case of G=Sp_4.
Project duration	8 Weeks
Expected outcomes	The expectation is that the student will do some computations to figure out if the number of points of the character variety of Sp_4 over a finite field F_q grows as a polynomial in q.
Suitable for	The Student is expected to have taken 3rd year algebra and complex analysis and at least one of fourth year number theory or advanced algebra.
Other important details (if applicable)	

Summer Research Scholarship program
2018 / 2019

Supervisor's name	Associate. Professor Ebinazar Namdas
Supervisor's contact details	e.namdas@uq.edu.au
Number of student places available	1
Project title ***SMP-18-VRP03***	Organic Light emitting diodes (OLEDs)
Project description	Organic Light Emitting Diodes (OLEDs) are a class of organic electronics, which is extensively being investigated because of its potential for flat---panel display and lighting. It's an attractive area of research particularly because they are lightweight, flexible, have wider viewing angles and a faster response time. Currently, they are also used in displays of smart phones. The performance of an OLED depends on various parameters such as thickness of the light emitting layer (organic semiconductor), buffer layer between electrode and emitting layers etc.
Project duration	8-10 weeks
Expected outcomes	In this project, you will gain an in-depth knowledge about the working of mechanism of OLEDs, and measurement technique and/or device modelling and simulation.
Suitable for	3rd year students Experimental Project requirement – Strong interest in Applied Physics, Engineering, Semiconductors, Optics
Other important details (if applicable)	Any other information you would like to include

Summer Research Scholarship program
2018 / 2019

Supervisor's name	Associate Professor. Ebinazar Namdas
Supervisor's contact details	e.namdas@uq.edu.au
Number of student places available	1
Project title *SMP-18-VRP04*	Organic Semiconductor Lasers
Project description	Lasers have many applications in all of the branches of science and technology -- they can weld, cut or drill, transmit phone calls through optical fibres, act as sensors, produce computer printouts and much more. Following the discoveries of luminescence and electroluminescence from organic semiconducting materials, the development of lasers using organic semiconductors became a major research activity around the world. Furthermore, use of organic semiconductors opens up the prospect of compact, tunable, low-cost, disposable lasers suitable for a wide range of applications. Almost all organic semiconductor lasers (OSL) reported have needed another laser (mainly bulky and expensive) to optically pump them to reach a threshold. This is a cumbersome and expensive configuration which has limited their usefulness. An alternative solution is to fabricate an optically pumped OSL that is optically pumped by compact inorganic diode laser. The main challenge is to reduce optical threshold for lasing. The aim of this project is to minimize the lasing threshold for OSL. In this project we will also exploit the feasibility of electrical pump lasing to potentially create the world's first organic injection lasing.
Project duration	8-10 weeks
Expected outcomes	In this project, you will gain an in-depth knowledge about the working of mechanism of OLEDs, and measurement technique and/or device modelling and simulation.
Suitable for	3rd year students Experimental Project requirement – Strong interest in Applied Physics, Engineering, Semiconductors, Optics
Other important details (if applicable)	Any other information you would like to include

Summer Research Scholarship program
2018 / 2019

Supervisor's name	Associate Professor. Ebinazar Namdas
Supervisor's contact details	e.namdas@uq.edu.au
Number of student places available	1
Project title ***SMP-18-VRP05***	LABVIEW programming for organic opto-electronics
Project description	LABVIEW is a visual programming software platform which is very often used to quickly setup the control of almost any electronic equipment. It is also widely used platform in industrial applications for process automation and fabrication, therefore the knowledge of it will turn out to be useful regardless of career choice in academics or in industry. The tasks of this project involve setting up the basic application to control the equipment in the laboratory for experiments on organic opto-electronics devices. Student will also become familiar with organic opto-electronics, device fabrication, measurements and their performance.
Project duration	8-10 weeks
Expected outcomes	In this project, you will gain an in-depth knowledge of LABVIEW, automation, working mechanism of organic opto-electronics devices and measurement techniques.
Suitable for	3rd year students Experimental Project requirement – Strong interest in LABVIEW, Matlab, Applied Physics, Electrical Engineering, and Semiconductors.
Other important details (if applicable)	

SMP Vacation Research Scholarship 2018 / 2019

Supervisor's name	Sally Shrapnel
Supervisor's contact details	s.shrapnel@uq.edu.au 0437 549 124
Number of student places available	2
Project title ***SMP-18-VRP06***	Explainable deep learning for healthcare
Project description	Using publically available healthcare data (MIMICIII) the student will (1) train a convolutional neural network to classify medical imaging data (2) interrogate the trained model using recent techniques (TCAV and LIME). The aim is to obtain explanations of the model's behaviour that will be relevant to clinicians.
Project duration	
Expected outcomes	Students will become proficient in using high level machine learning programming languages (keras and tensorflow) to build and test neural network models. Students will be introduced to working with health-related data sets and communicating with health-care professionals.
Suitable for	Relevant programming experience. Should be comfortable with python and associated libraries (e.g. numpy, pandas). Basic knowledge of statistics would be beneficial.
Other important details (if applicable)	

SMP Vacation Research Scholarship 2018 / 2019

Supervisor's name	Dr Tyler Neely
Supervisor's contact details	t.neely@uq.edu.au
Number of student places available	1
Project title *SMP-18-VRP07*	Art with Matter Waves: Artistic Media Moves into the Quantum Realm
Project description	In the Bose-condensation lab at UQ (http://bec.equs.org), we cool small samples of gas to nearly absolute zero, resulting in Bose-Einstein condensates (BECs). In this state of matter, the strange quantum-nature of the atoms composing the BEC is manifest. In particular, the atoms in the BEC can no-longer be considered point-particles --- instead best described as a giant matter-wave. We have developed exquisite techniques to manipulate and sculpt our matter waves (some examples can be found at https://bec.equs.org/news/art-bec). These examples represent an exciting opportunity for creative expression --- in the history of humanity, physical media have always belonged to the classical-physics world of our everyday experience. Here, a new medium governed by quantum mechanics is available for the first time. The aim of this unconventional research project is to understand what this means in the context of art and science to date. How does this compare to other examples of scientifically inspired/collaborative art? Can this be placed in that context and is it truly unique? What form can this take to best interact with and also inform the general public? The overall aim of this project is to develop a project brief for presenting to institutions such as the Queensland Museum.
Project duration	8 weeks
Expected outcomes	Learning the basics of BEC physics, developing skills in scholarly research, basic coding and data analysis, laboratory skills (if relevant).
Suitable for	Any student, preferably with an interest/background in modern art, and some exposure to science coursework.
Other important details (if applicable)	Please contact Dr Tyler Neely above for additional inquiries, and to discuss the details of the project prior to applying.

SMP Vacation Research Scholarship 2018 / 2019

Supervisor's name	Professor Jerzy Filar, Wen-Hsi and Sabrina Streipert
Supervisor's contact details	j.filar@uq.edu.au, Room 69-815, X52236
Number of student places available	Two students working on this project would be the maximum number.
Project title *SMP-18-VRP08*	Testing the impact of environmental factors on fishery stock assessment models.
Project description	This project will be linked to the recently awarded SWIF project entitled "Incorporating abiotic environmental factors into both detailed and rapid stock assessment models of fisheries to support management decisions". In particular, the student(s) will fit statistical models to real fisheries data to develop adjustments to existing stock assessment models to reflect the fluctuating impacts of abiotic environmental factors. For instance, factors such as sea-surface temperatures or river flows may strongly influence the stocks of species such as saucer scallop and barramundi, respectively. However, to date, these have not yet been implemented in the standard stock assessment models, and there are multiple, alternative, ways of incorporating their impacts. The project supervisors will be working on these problems as part of their SWIF project and would welcome an opportunity to have students test various modelling ideas as they emerge. A deeper understanding of the influence of environmental factors on stocks will support management decisions to tighten, or relax, harvest regulations. This is increasingly important as climate change could be driving persistent trends in these factors that will lead to geographical shifts of fish stocks. The scientific challenge lies in quantifying the correct, evidence based, responses to fluctuations in the environmental factors that will benefit both the fishing industry and the sustainability of the harvested species. We intend to address this challenge by examining how to best incorporate environmental factors into both detailed (age/length structured) stock assessment models and the emerging new generation of rapid (Bayesian biomass) stock assessment models.
Project duration	We envisage that the student project will run for 8 weeks selected during the period mid-November 2018 to mid-February 2019. Some flexibility exists in the precise scheduling of tasks for the right students.
Expected outcomes	Students will gain modelling, data fitting and statistical and data analysis and interpretation skills. These will include programming in R and acquiring familiarity with some specialised stock assessment software packages.
Suitable for	Students with strong results in their statistics, modelling and programming courses and desire to apply their quantitative skills to real world problems.
Other important details (if applicable)	Students may need to interact with staff from the Department of Agriculture and Fisheries. Hence strong communication and interpersonal skills would be very desirable.

SMP Vacation Research Scholarship 2018 / 2019

Supervisor's name	Ramiro Lafuente
Supervisor's contact details	r.lafuente@uq.edu.au, phone 336 57506, office 69-713
Number of student places available	2
Project title ***SMP-18-VRP09***	Closed geodesics on Euclidean homogeneous spaces
Project description	Since the beginning of global differential geometry in the early 1900's, the question of existence of closed geodesics on Riemannian manifolds has been actively studied and it has motivated a great amount of research in the area. A curve in a Riemannian manifold is a geodesic if it locally minimizes distances, and is called closed if it returns to the starting point with the same initial direction. They are of great importance in geometry as they usually allow to control the geometry and topology of a space, and also in general relativity. Moreover, understanding them is usually key when studying the collapsing behaviour of sequences of Riemannian manifolds. In this research project we are interested in the existence of closed geodesics on Riemannian manifolds which are homogeneous. Homogeneous spaces are among the nicest examples of Riemannian manifolds: they have so much symmetry that the geometry looks the same at every point. While the existence of closed geodesic on compact homogeneous spaces has been studied by W. Ziller in the 70's, there seems to be a lack of results in the non-compact case. In particular, the question of whether a homogeneous space diffeomorphic to R^n admits a closed geodesic remains open to this day. The expected negative answer would provide a simplified proof of the non-collapsing of such spaces under natural notions of convergence. The aim of this project is to study geodesics on low-dimensional homogeneous spaces. More precisely, the main goal is to prove non-existence of closed geodesics for invariant Riemannian metrics on some of the eight Thurston's three-dimensional model geometries. Due to its large symmetry, information about the corresponding Lie algebras would help understanding the global properties of geodesics on these spaces.
Project duration	8 weeks
Expected outcomes	The scholar will learn the basic notions of homogeneous differential geometry, and this will allow him/her to tackle special instances of an open problem in the field.
Suitable for	Self-motivated, second or third-year mathematics students with a background in basic differential geometry of curves and surfaces, who are interested in pursuing research in the area.
Other important details (if applicable)	

SMP Vacation Research Scholarship 2018 / 2019

Supervisor's name	Ramiro Lafuente
Supervisor's contact details	r.lafuente@uq.edu.au, phone 336 57506, office 69-713
Number of student places available	2
Project title ***SMP-18-VRP10***	The curve shortening flow
Project description	Geometric flows are one of the main trends in modern differential geometry, with a rich history of past and recent success highlighted by Perelman's proof of the Poincare conjecture in 2002-03. Unfortunately, treating these topics in detail usually requires some knowledge in Riemannian geometry and PDEs which is uncommon for undergraduate students. An exception to this is the most basic of these evolution equations, namely the curve shortening flow: an evolution equation in which a plane curve evolves in time so as to shorten its length as fast as possible. The goal of the project is to study material including research articles on this flow, with a focus on understanding its main properties, its self-similar and ancient solutions, and its numerous applications to pure mathematics and beyond.
Project duration	8 weeks
Expected outcomes	The scholar will familiarise him/herself with the type of questions and ideas of geometric analysis, while at the same time strengthening his/her knowledge of differential geometry and differential equations.
Suitable for	Self-motivated, second or third-year mathematics students with a background in the geometry of curves, who are interested in pursuing research in differential geometry.
Other important details (if applicable)	

SMP Vacation Research Scholarship 2018 / 2019

Supervisor's name	Dr Itia Favre-Bulle
Supervisor's contact details	i.favrebulle@uq.edu.au +61 7 336 53411 Room 427 Physics annexe
Number of student places available	1
Project title ***SMP-18-VRP11***	Multiple particle tracking
Project description	Particles interactions or behaviours tracked by cameras are only resolvable up to camera bandwidth. Unfortunately commercial systems over a few kHz are often both expensive and too slow to resolve some phenomena. The aim of this project is to track multiple micro-particles independently at very high speed with non-expensive devices.
Project duration	8 weeks
Expected outcomes	The Scholars will gain experience in handling and running optical systems, handling micro-sized particles, and improving their skills in programming.
Suitable for	The Scholars need to have a physics background with skills in programming such as Matlab.
Other important details (if applicable)	None

SMP Vacation Research Scholarship 2018 / 2019

Supervisor's name	Dr Itia Favre-Bulle
Supervisor's contact details	i.favrebulle@uq.edu.au +61 7 336 53411 Room 427 Physics annexe
Number of student places available	1
Project title ***SMP-18-VRP12***	Bacteria tracking and study
Project description	Swimming modalities of many natural swimmers are not well understood. The aim of this project is trapping and tracking bacteria to study their swimming speeds depending on their environment.
Project duration	8 weeks
Expected outcomes	The Scholars will gain experience in handling and running optical systems, handling bacteria, and improving their skills in programming.
Suitable for	The Scholars need to have a physics background with skills in programming such as Matlab.
Other important details (if applicable)	None

SMP Vacation Research Scholarship 2018 / 2019

Supervisor's name	Professor Matthew Davis / Professor Margaret Mayfield
Supervisor's contact details	Physics Annexe 06-309 mdavis@physics.uq.edu.au
Number of student places available	2
Project title ***SMP-18-VRP13***	Statistical physics model of abundances and interactions in plant communities
Project description	This project aims to use the methods of statistical physics to help understand the equilibrium and dynamics and of interacting plant communities with Prof Margie Mayfield in the School of Biological Sciences. Prof Mayfield's group has collected a significant amount of data on plant abundances, and shown that the data suggests that nonlinear interactions between the plants affect their seed production. We hope to gain a new understanding of this data using equilibrium models of statistical mechanics. See: Higher-order interactions capture unexplained complexity in diverse communities Margaret M. Mayfield & Daniel B. Stouffer Nature Ecology & Evolution 1, Article number: 0062 (2017) doi:10.1038/s41559-016-0062
Project duration	6 – 10 weeks
Expected outcomes	Hopefully we will show that physics methods can be used to help understand the interactions between plants in a community.
Suitable for	Self-motivated third year science students with strong quantitative skills who are interested in pursuing an interdisciplinary project covering theoretical physics and biology.
Other important details (if applicable)	Please get in touch with Professor Davis before applying for this project.

SMP Vacation Research Scholarship 2018 / 2019

Supervisor's name	Professor Matthew Davis / Dr Matt Reeves
Supervisor's contact details	Physics Annexe 06-309 mdavis@physics.uq.edu.au
Number of student places available	2
Project title ***SMP-18-VRP14***	Nonequilibrium superfluid flows
Project description	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.
Project duration	6 – 10 weeks
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.
Suitable for	Self-motivated third year physics students who are interested in pursuing research in theoretical and computational quantum physics.
Other important details (if applicable)	Please get in touch with Professor Davis before applying for this project.

SMP Vacation Research Scholarship 2018 / 2019

Supervisor's name	Professor Matthew Davis / Dr David Colas
Supervisor's contact details	Physics Annexe 06-309 mdavis@physics.uq.edu.au
Number of student places available	2
Project title ***SMP-18-VRP15***	Pairing phase of the attractive Bose gas
Project description	In the 1970s there was speculation that the cause of superfluidity in helium-4 was not due to Bose-Einstein condensation, but a form of Cooper pairing between attractive bosons, similar to that which occurs for electrons in superconductors. More recent calculations for the homogeneous system suggest that the temperature for the pairing transition is higher than for BEC - but that both are preceded by the mechanical collapse of the gas. This collapse is however prevented in finite systems. This project will use the classical field method to determine whether a pairing phase is possible for degenerate Bose gas with attractive interactions, and compare the results to the predictions of the Hartree-Fock-Bogoliubov method.
Project duration	6 – 10 weeks
Expected outcomes	The student will learn how to apply analytical and computational quantum-many body methods to Bose-Einstein condensates. The hope is to uncover a new possible phase of matter, and to describe how to observe it in the laboratory.
Suitable for	Self-motivated third year physics students who are interested in pursuing research in theoretical and computational quantum physics.
Other important details (if applicable)	Please get in touch with Professor Davis before applying for this project.

SMP Vacation Research Scholarship 2018 / 2019

Supervisor's name	Professor Matthew Davis / Dr Matt Reeves
Supervisor's contact details	Physics Annexe 06-309 mdavis@physics.uq.edu.au
Number of student places available	2
Project title ***SMP-18-VRP16***	Superfluidity under a quench of interaction strength in a persistent current.
Project description	One of the key insights of Landau was to derive a phenomenological formula for the critical velocity in a superfluid. In a Bose gas this is related to the speed of sound, which is directly related to the strength of repulsive interaction between particles. By making use of something known as a "Feshbach resonance" in the scattering properties of two atoms, it is experimentally possible to tune the strength of interactions in a Bose gas. This project will look at a ring system in which there exists a persistent current that if left undisturbed will never decay. However, if the interaction strength is sufficiently reduced, the speed of sound will decrease below the speed of the current and the superflow will break down. This project will characterize the non-equilibrium dynamics as the flow breaks down and thermalizes. It should be able to be related to the well-known "Kibble-Zurek" mechanism for phase transitions.
Project duration	6 – 10 weeks
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 third year physics students who are interested in pursuing research in theoretical and computational quantum physics.
Other important details (if applicable)	Please get in touch with Professor Davis before applying for this project.

Supervisor's name	Professor Matthew Davis / Dr Mark Baker / Dr Tyler Neely
Supervisor's contact details	Physics Annexe 06-309 mdavis@physics.uq.edu.au
Number of student places available	2
Project title ***SMP-18-VRP17***	Interactions of polar core vortices in a ferromagnetic spin-1 Bose-Einstein condensate
Project description	One of the features of superfluids is that the can only rotate via the formation of quantised vortices. Laboratory experiments with single component Bose-Einstein condensates can now create and manipulate single vortices at will, and these techniques have been used to study the properties of two-dimensional quantum turbulence. This project will numerically study the properties of polar-core vortices in a spin-1 Bose-Einstein condensate –a superfluid that has three different components. The properties of vortices in this system are not well understood. This project will map out the the energy of interaction of two polar core vortices as a function of distance, as well as the energy required to stretch the vortex core and determine if the can dissociate into free vortices.
Project duration	6 – 10 weeks
Expected outcomes	The student will learn how to apply computational methods to find excited states of nonlinear Schrodinger equation with three components and spin-changing collisions. A complete set of results with appropriate interpretation could be turned into a publication.
Suitable for	Self-motivated third year physics students who are interested in pursuing research in theoretical and computational quantum physics.
Other important details (if applicable)	Please get in touch with Professor Davis before applying for this project.

SMP Vacation Research Scholarship 2018 / 2019

Supervisor's name	Professor Warwick Bowen and Nicolas Mauranyapin
Supervisor's contact details	w.bowen@uq.edu.au
Number of student places available	1
Project title *SMP-18-VRP18*	Deep learning enhanced microscopy
Project description	At sub-cellular scale, biological systems seethe with motion, from the motor molecules that transport nutrients along microtubules to neurotransmitter receptors the motion of which is important for neural plasticity. Measurements that track the motion of biological targets over time are crucial, and widely used to understand these important processes. However, the clutter of organelles and other components in a biological specimen often make it challenging to effectively and accurately track targets. This project will employ deep learning approaches to train a neural network to distinguish the target from the clutter, and therefore improve our ability to track biological dynamics.
Project duration	8 weeks
Expected outcomes	The scholar should expect to learn about machine learning and artificial intelligence. Most specifically, how to apply deep learning algorithms to train a neural network to out-perform conventional methods of imaging analysis. The scholar should, further, expect to learn the state-of-the-art in approaches to track biological targets. Should the project be successful, it may result in a peer-reviewed publication.
Suitable for	This project is open to year 2-4 students with a background in physics and with a solid foundation of programming in Matlab, and ideally some prior experience in deep learning.
Other important details (if applicable)	Applicants would be encouraged to register their interest to Prof Bowen to applying, w.bowen@uq.edu.au

SMP Vacation Research Scholarship 2018 / 2019

Supervisor's name	Dr Jacinda Ginges
Supervisor's contact details	j.ginges@uq.edu.au Room 330 Physics Annexe
Number of student places available	3
Project title ***SMP-18-VRP19***	Modelling quantum electrodynamic corrections to the hyperfine structure
Project description	Precision studies of fundamental physics in heavy atoms, including tests of the standard model of particle physics and searches for new physics beyond, rely on high-accuracy description of atomic wave functions. In this project, we will develop a method to model quantum electrodynamics (QED) corrections to the hyperfine structure in heavy atoms. This will help with the description of the atomic wave functions in the nuclear region.
Project duration	6-10 weeks
Expected outcomes	Development of a reliable method for modelling QED corrections in heavy atoms. Successful completion of this project may lead to publication in an international peer-reviewed journal.
Suitable for	Students should have a strong background in quantum mechanics and an ability to work on both analytical and numerical problems.
Other important details (if applicable)	Please discuss the project with Dr Ginges before applying.

SMP Vacation Research Scholarship 2018 / 2019

Supervisor's name	Dr Jacinda Ginges
Supervisor's contact details	j.ginges@uq.edu.au Room 330 Physics Annexe
Number of student places available	2
Project title ***SMP-18-VRP20***	Quantum electrodynamics and highly-charged ion clocks
Project description	The definition of the unit for time — the second — is based on the ground-state hyperfine transition in cesium. Higher accuracy has been demonstrated in clocks based on optical transitions in neutral and near neutral atoms. An even greater gain may be achievable in optical transitions in highly-charged ions (HCI). As well as their appeal for metrology, HCI clocks offer a sensitive probe of possible new physics such as variation of fundamental constants. Realising HCI clocks is a challenge for experiment and theory. The optical transitions of interest are small on the scale of typical HCI binding energies, and highly-accurate calculations — beyond the level currently achieved in neutral atoms — are required. The accurate account of quantum electrodynamic (QED) radiative corrections is particularly important. This project will involve the construction of a "radiative potential" — which allows one to take into account QED effects in complex many-electron atoms — that is suitable for use in highly-charged ions.
Project duration	6-10 weeks
Expected outcomes	Construction of a "radiative potential" appropriate for modelling QED corrections to the energies for highly-charged ions. Successful completion of this project may lead to publication in an international peer-reviewed journal.
Suitable for	Students should have a strong background in quantum mechanics and an ability to work on both analytical and numerical problems.
Other important details (if applicable)	Please discuss the project with Dr Ginges before applying.