Faculty of Science
Summer Research Scholarships

2026/2027 Projects (Mathematics)

Project code:	SCI059
Project title:	**The Role of Gesture in Mathematical Understanding**
Discipline:	Mathematics
Supervisor(s)	Ofer Marmur
Contact details	ofer.marmur@auckland.ac.nz
Skills Needed	• Applicants should be interested in mathematics education, and curious to learn about research on the role of gestures in mathematical thinking and communication.

Project description

Mathematics teaching involves much more than spoken and written language. Teachers and lecturers also communicate mathematical meaning through gestures and bodily movements, for example when describing limits, graphs, or transformations. Such gestures can play an important role in how mathematical ideas are communicated and understood, yet they often remain unnoticed or underexamined.

This project will investigate how mathematical concepts and ideas are communicated through gestures in mathematics instructional videos available online. The student will collect and analyse selected video episodes, focusing on how lecturers use gestures alongside speech, writing, and other visual representations to convey mathematical meaning. By closely examining how lecturers communicate mathematics through gesture, the project's aim is to deepen our understanding of how the teaching and learning of abstract mathematical ideas can be enriched and improved.

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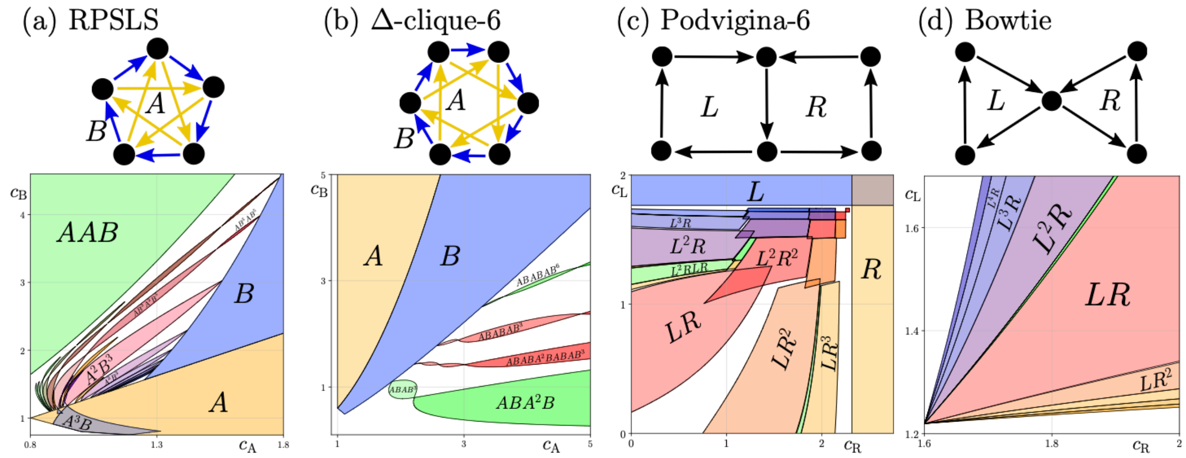
2026/2027 Projects (Mathematics)

Project code:	SCI060
Project title:	**Switching near heteroclinic networks**
Discipline:	Mathematics
Supervisor(s)	Claire Postlethwaite
Contact details	c.postlethwaite@auckland.ac.nz
Skills Needed	• Maths 260 and Maths 270, particularly an understanding of numerical solutions to differential equations, would be useful.

Project description

Heteroclinic networks are special solutions to dynamical systems which are associated with intermittent dynamics – solutions spend a long time near a particular state before switching to another. The route a solution takes between the different states around a heteroclinic network may be simple, but can be extremely complex, or even chaotic. This project will use a new method for the analysis of heteroclinic networks, called a “projected map”, to investigate the potential routes that may be taken by trajectories near networks with five or six nodes.



A selection of heteroclinic networks (top) and parameter space (bottom) showing parameter regions where different routes around the network are observed.

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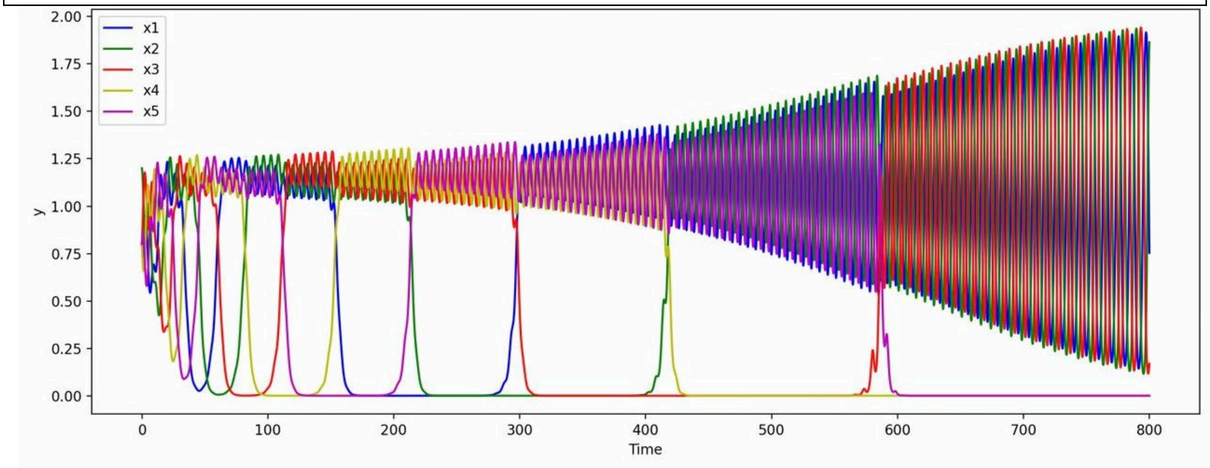
2026/2027 Projects (Mathematics)

Project code:	SCI061
Project title:	**Sonification of heteroclinic networks**
Discipline:	Mathematics
Supervisor(s)	Claire Postlethwaite
Contact details	c.postlethwaite@auckland.ac.nz
Skills Needed	• A background or interest in signal processing and digital audio production would be helpful. Maths 260 and Maths 270, particularly an understanding of numerical solutions to differential equations, would be useful.

Project description

Heteroclinic networks are special solutions to dynamical systems which are associated with intermittent dynamics – solutions spend a long time near a particular state before switching to another. In this project, we will consider the transient behaviour as trajectories approach a heteroclinic network. We will then interpret this time series not simply as a set of data, but as an audio signal. This then allows us to ask the question: what do the dynamics sound like? This project will involve developing an interactive piece of computer software which generates an audio signal in real time. Users will be able to alter the system by changing parameters, nudging the system with small inputs, or even by singing into a microphone.



A time series near a heteroclinic network. What would this sound like if we listened to it?

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2026/2027 Projects (Mathematics)

Project code:	SCI062
Project title:	**Finding equiangular lines and their (projective) symmetries**
Discipline:	Mathematics
Supervisor(s)	Shayne Waldron
Contact details	waldron@math.auckland.ac.nz
Skills Needed	• Linear algebra and Maths 320

Project description

There are three equiangular lines in R^2 (there cannot be more), and there are four equiangular lines in C^2 (there cannot be more). Recently, it has been shown that there are six equiangular lines in H^2 (there cannot be more), where H is the quaternions.

The aim of this project is to study quaternionic equiangular lines, specifically to find examples in more than two dimensions. In particular, finding a set of ten to fifteen equiangular lines in H^3 would be a very interesting new result.

This project requires linear algebra over the quaternions (an extension of the complex numbers, for which multiplication is not commutative). It is likely that such lines can be constructed as orbits of groups of matrices over the quaternions (e.g., reflection groups). To do this, a symbolic algebra package such as maple or magma will be used.

Project code:	SCI063
Project title:	**The combinatorics of the reflection subgroups of a reflection group**
Discipline:	Mathematics
Supervisor(s)	Shayne Waldron
Contact details	waldron@math.auckland.ac.nz
Skills Needed	• Linear algebra and Maths 320

Project description

Reflections on R^d or C^d are invertible linear maps which fix a hyperplane (the vector orthogonal to the hyperplane is called a root) and have finite order. The finite (irreducible) groups generated by reflections are called reflection groups. The reflection groups have been classified by Shephard and Todd. A classical theorem of Steinberg says that the parabolic subgroups of a reflection group (those which pointwise fix a subset/subspace) are reflection groups, which are necessarily reducible and not normal. These are the most studied reflection subgroups.

Recently, the normal subgroups of reflection subgroups have been considered, and I have shown that they form a lattice with a natural indexing. A geometric interpretation of these subgroups says they are obtained by taking the matrix obtained by conjugating the vector of reflections for a given root and removing appropriate rows. All the other (non-normal) subgroups are obtained by removing some columns. The basic sets of reflections that can be removed to give reflection subgroups are called "dominos". The aim of this project is to calculate, using the computer algebra system magma, all the dominos for the complex reflection groups. Once this is done, the dominos giving each reflection subgroup (up to conjugacy) will determined. From this domino decomposition, one can easily read of inclusions between the reflection subgroups and their number of conjugates.

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2026/2027 Projects (Mathematics)

Project code:	SCI064
Project title:	**How Do We Know a Number Is Prime?**
Discipline:	Mathematics
Supervisor(s)	Steven Galbraith Gaurish Korpal
Contact details	s.galbraith@auckland.ac.nz
Skills Needed	• MATHS 254 or COMPSCI 225. MATHS 320 or 328 preferred. Some programming skills (eg python)

Project description

Modern algorithms can rapidly identify numbers that are probably prime, and such methods are widely used in computation. However, computational evidence alone does not constitute a mathematical guarantee. To establish certainty, one must instead provide a proof that can be independently verified. This project explores the concept of certified primality: explicit mathematical evidence that a number is prime, structured so that its correctness can be checked.

You will learn about the structure of the integers modulo n, subsequently implementing algorithms for constructing and verifying simple primality certificates. You will then use the LEAN theorem prover to formalize key definitions and verify correctness proofs of certificate-checking procedures, bridging informal mathematical reasoning with machine-checked arguments.

The project develops an understanding of how classical number-theoretic reasoning can be transformed into computational procedures and formally verified mathematics.

Project code:	SCI065
Project title:	**Coxeter groups and related Condorcet domains**
Discipline:	Algebra
Supervisor(s)	Arkadii Slinko Jeroen Schillewaert
Contact details	a.slinko@auckland.ac.nz, j.schillewaert@auckland.ac.nz
Skills Needed	• MATHS 320 or MATHS 328

Project description

Condorcet domains, which originated in economics, have turned out to be closely related to various algebraic and combinatorial structures. Their connection to the symmetric group Sn is well known. Since Sn is a Coxeter group of type A, this project aims to investigate Condorcet domains associated with Coxeter groups of other types.

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2026/2027 Projects (Mathematics)

Project code:	SCI066
Project title:	**Modelling active fluids**
Discipline:	Mathematics
Supervisor(s)	Priya Subramanian
Contact details	priya.subramanian@auckland.ac.nz
Skills Needed	• Some ideas on bifurcations and programming experience are desirable

Project description

Active fluids occur in different systems, from animal herds, schools of fish, flock of birds, insect swarms and bacterial colonies. We want to consider the over-damped dynamics of a collection of such particles when they are also subject to close range interactions with their neighbours that align them. A mean-field description of such a system involves describing the evolutions of the self-propulsion speed, and a measure of the nonlinear interaction.

Two dimensional computations of the model will allow us to explore the parameter space and identify the possible structures that can arise. An introduction to numerical methods and some programming is desirable for this project.

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2026/2027 Projects (Mathematics)

Project code:	SCI067
Project title:	**Bridges between pattern formation and numerical algebraic geometry**
Discipline:	Mathematics
Supervisor(s)	Priya Subramanian
Contact details	priya.subramanian@auckland.ac.nz
Skills Needed	• Some ideas on bifurcations and programming experience are desirable

Project description

The study of regular and coherent spatio-temporal structure in nature has fascinated scientists for centuries, ranging from the formation of regular chemical precipitates to solitary waves, or to the studies in biological form and structure. Arising out of these various disciplines, including dynamical systems, partial differential equations, and numerical computing, the mathematical study of patterns has blossomed over the past 70 years, with patterns being observed and studied in nearly every area of science, from fluids, chemistry, material science, ecology, and numerous areas of biology.

Researchers have paired various types of numerical approaches, including time-stepping and numerical continuation, along with formal asymptotic and rigorous techniques to characterize phenomena. Highlights include using "most-unstable mode" analysis of the linearized equation about an unstable equilibrium to predict the type of pattern formed in the full system. A step further, researchers use weakly-nonlinear analysis, expanding solutions in some basis at onset of an instability and truncating to obtain a finite-dimensional ODE system to describe the nonlinear dynamics.

Truncating to a finite dimensional coupled ODE system is used often to analyse a pattern forming system in a weakly nonlinear limit. Solutions of the resulting ODE system then are good numerical approximations to the solutions of the associated full nonlinear PDE system. Equilibria of the coupled nonlinear polynomial equations that constitute the ODE system can be obtained in a globally convergent way using computational algebraic geometry. Such a global method uses homotopy to obtain all solutions over the complex field with no initial guesses. This approach allows us to obtain (i) disconnected solution branches which might be hard to obtain using numerical continuation, and (ii) obtain multiple solutions with the chosen symmetry at the same parameters. Reduced symmetry subgroups can also be considered with minor modifications, thus allowing for a detailed exploration of the rich solution landscapes of pattern forming systems in multi-dimensions.

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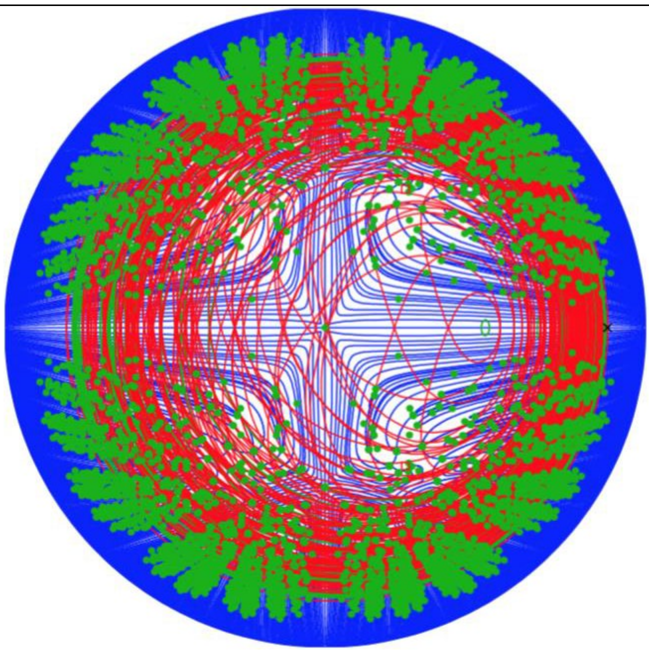
2026/2027 Projects (Mathematics)

Project code:	SCI068
Project title:	**Fingerprints of Wild Chaos**
Discipline:	Mathematics
Supervisor(s)	Hinke Osinga
Contact details	h.m.osinga@auckland.ac.nz
Skills Needed	• Maths 260 and good Matlab or Python coding skills

Project description

Wild chaos is a new form of unpredictable behaviour that can occur in higher-dimensional dynamical systems. Only very few examples are known, but a previous summer project student discovered a measure of wild chaos that can identify such behaviour in experiments. Your task will be to test the approach on data that is thought to come from a wild chaotic attractor in a three-dimensional discrete dynamical system, defined by a map. If it works, what happens as parameters change and wild chaos is lost?



Chaotic attractor

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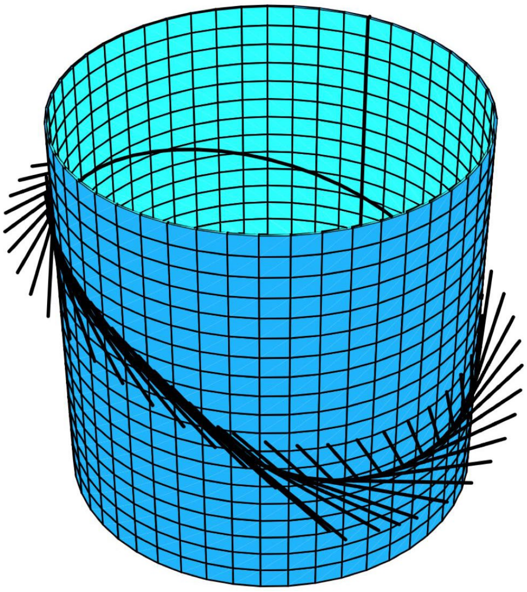
2026/2027 Projects (Mathematics)

Project code:	SCI069
Project title:	**Computing an invariant torus with Chebfun**
Discipline:	Mathematics
Supervisor(s)	Hinke Osinga
Contact details	h.m.osinga@auckland.ac.nz
Skills Needed	• Maths 162, Maths 250, and good Matlab coding skills

Project description

Chebfun is an extension to Matlab that allows for arithmetic operations on functions, performed to machine precision, using Chebyshev polynomials. Recent updates include periodic function approximations. Your task will be to develop a new application of Chebfun for the computation of an invariant closed curve, or torus, in a two-dimensional discrete dynamical system, defined by a map. In two dimensions, the torus will be either attracting or repelling. Are you up for the challenge of doing it for a three-dimensional system when the torus can be of saddle type?



Invariant closed curve

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2026/2027 Projects (Mathematics)

Project code:	SCI070
Project title:	**Mathematical modelling of nitrogen transport from farms**
Discipline:	Mathematics
Supervisor(s)	Steve Taylor
Contact details	s.taylor@auckland.ac.nz
Skills Needed	• Differential equations • Statistics

Project description

Mathematical modelling of nitrogen and other pollutants in farming catchments in NZ with a goal of managing nitrogen pollution in our waterways.
The distinguishing feature of this project is that it takes measurements of other pollutants into account to better estimate nitrogen transport as it passes through the catchment. We hope that this will allow more accurate modelling of nitrogen transport with fewer sensor readings. Data and a preliminary model will be provided as a starting point.

Project code:	SCI071
Project title:	**Moment problem and matrix completions**
Discipline:	Mathematics
Supervisor(s)	Jurij Volčič
Contact details	jurij.volcic@auckland.ac.nz
Skills Needed	• Maths 221/254 and Maths 332/333 • Dexterous with Matlab, excited about advanced linear algebra

Project description

The moment problem asks whether a sequence of real numbers arises from moments of a probability distribution. While this problem has a clear resolution for distributions on the real line, its solvability on the real plane is more intricate. It is related to certain infinite positive semidefinite matrices, and the growth of their entries. This project explores the boundary of moment problem solvability by investigating completions of positive semidefinite matrices, and the constraints they impose on the entries.