Conference Booklet

NZMASP - Wellington 2023

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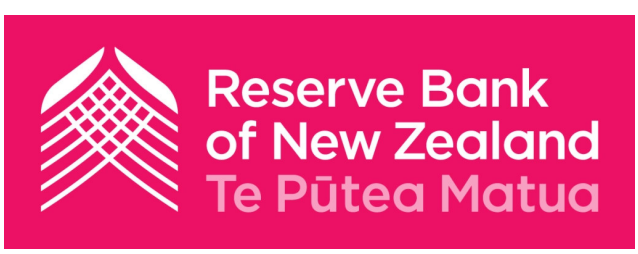

Contents

Chapter 1

Important information

1.1 Contact numbers

For general, non-urgent enquiries, please contact us via our email: nzmasp2023@vuw.ac.nz

The conference organisers may be contacted using the details below:

- Samuel Bastida: 021 207 8398 or samuel.bastida@vuw.ac.nz
- Sapir Ben-Shahar: 021 214 8511 or sapir@ben-shahar.com
- Mark Bishop: 027 307 4650 or mark.bishop@vuw.ac.nz
- Laia Egea Cortes: 022 438 6598 or egeaclaia@myvuw.ac.nz
- Malcolm Jones: 027 420 0939 or malcolm.jones@vuw.ac.nz
- Shonaugh Wright: 027 844 0428 or shonaugh.wright@vuw.ac.nz

Other important contacts are:

- Wellington police station: 105 (111 for emergencies)
- Wellington After Hours Medical Centre: 04 384 4944 (111 for emergencies)
- Corporate Cabs Wellington: 0800 789 789
- Wellington Combined Taxis Limited: 04 384 4444
- 'Safe to talk' national sexual harm helpline: 0800 044 334

1.2 Accommodation

The accommodation we have organised is at Trek Global Backpackers Wellington from the 28th November to 2nd December. Check in time is anytime from 2pm, so feel free to arrive any time after that. Check out time is 10 am. When checking in you will need to present photo ID. Note that Trek does **not** accept Student IDs. There are a few terms and conditions for staying at Trek (see here for the full list).

- Guests and their visitors may not consume or store food and drinks (other than water or items placed by the backpacker within the room) in their rooms. Alcohol may be consumed in common areas until 11pm each night. Alcohol can not be consumed in the guests room at any time. Smoking and vaping is not permitted at any time inside the hostel and only in the designated smoking areas.
- Cooking facilities and dining areas are available in all wings until 11pm each night. After 11pm the ground floor kitchen and reception area is available only.
- Guests are required to conduct themselves and ensure that their Guests conduct themselves in a reasonable and responsible manner at the hostel and must not act in any way which may disturb other guests. Failure to adhere to this requirement may result in Guests being asked to leave the hostel.

If you will be arriving outside of these hours, please let us know so that we can pass the information on and ensure you can get in.

The accommodation is at
9 O'Reily Avenue, Te Aro, Wellington 6141
04 471 3480

Parking

Onsite secure parking at Trek is available for $28 per night – this is limited and would need to be pre-booked. At the Royal Society venue there is no onsite parking but there is metered street parking on Murphy Street.

1.3 Venue

The conference will be held in Wellington at the Royal Society of New Zealand (11 Turnbull Street, Thorndon, Wellington 6011). From the accommodation, it is a 30min walk through the CBD. If you wish to catch a bus, we suggest:

- The 14 from Manners Street at Willis Street to Molesworth Street - Motorway (5 mins of walking)
- The 84 from Manners Street at Willis Street to Molesworth Street (near 95) (5 mins of walking)
- The 1 from Manners Street at Willis to Thorndon Quay - Capital (Opposite) (10 mins of walking)

We recommend checking the Metlink website for up to date information about delays/cancellations.

It is about a 13 minute scooter ride to the venue. In Wellington Beam and Flamingo scooters are able to be rented.

1.4 Information for presenters

Most attendees at NZMASP 2023 will be giving a presentation. Some talks will be 15 (or 7) minutes in length, followed by 5 (or 3) minutes question time. Presentations by the plenary speakers will be 60 minutes in length (including question time). Refer to the programme in chapter 2 of this booklet to see how long we have scheduled for your talk.

Tips for your presentation

- Keep it simple. Most of the audience will not be experts in your particular field. In fact, a large portion of your audience won't know more about your field beyond an undergraduate level, so please keep these people in mind.
- Less is more. You have limited time and your audience have limited attention; you may want to focus on a small aspect of your research and explain it well.
- Ensure that slides will be readable from the back of the room. Equations can take effort to read; use them when appropriate but don't go overboard.
- If you use videos or any non-standard tech, have them open and ready to go and have a back-up plan if it doesn't work.
- Practise your talk. Know what you are going to say, and how long it will take.
- Look at the audience, and make eye contact. Pause and take a breath between paragraphs or slides. Try to have fun :)
- Taking questions after the talk is important, but it is okay to not know all the answers. If you're stuck for an answer, say you don't know off the top of your head and follow up later.
- Acknowledge the people and organisations which have contributed to the work you present; supervisors, collaborators, funding etc.

Slides

We encourage presenters to upload their slides to the google drive folder using this link. (Please put your talk in the folder labeled with the day of your presentation.) If possible, please format your slides as a pdf and include animation files separately.

Presenters may also:

- bring their slides on a USB drive
- bring their own device if they want to use a specific program.

If presenters are bringing their slides on a USB or using their own device then please get in touch with a member of the committee in the break before the session with your talk.

Recording

We will not be recording any of the presentations. Participants are welcome to film/record their own talk if they so desire. Please do not make a recording of someone else's talk without their enthusiastic permission.

1.5 Information for session chairs

The conference organisers wish to thank all of the volunteer session chairs, as they greatly help with the running of the conference.

Role description

Session chairs are each in charge of a session involving 3-4 student speakers. Their main job is to introduce each speaker and let them know if they are running out of time. After each talk, they should ask the audience if there are any questions and have a question prepared themselves in case nobody from the audience asks one. The question can be something general, such as "how did you become interested in this topic" if a speaker's talk is outside the chair's expertise.

When introducing a speaker, please be mindful of their pronouns. If you are unaware of a person's pronouns, please use gender-neutral language when referring to them.

1.6 Prizes

The NZMASP conference will award prizes to recognise the most outstanding student speakers. The prizes are voted for by the audience and a voting form will be made available at the end of the conference. While listening to the presentations, please keep a note of any talks you may wish to vote for. Towards the end of the conference, we will post a Google form to allow you to allocate your votes for each different category.

The winner of each prize will receive a monetary reward as well as a year of free access to Wolfram|One Personal Edition and a one-year free subscription to Wolfram|Alpha Pro courtesy of our sponsors.

Rules and criteria

- You may not vote for yourself (please be impartial)
- When calculating the subject prize winners, your first preference vote is worth two points, whereas your second preference vote is worth one point.
- Votes are due by 5:15pm on Friday the 1st of December

Prizes available

Overall prizes

- The Reserve Bank of New Zealand (RBNZ) prize for the best overall student presentation
- Runner up best overall student presentation

Best Honours student presentation

Best Masters student presentation

Subject prizes for pure mathematics

- The New Zealand Mathematical Society (NZMS) prize for the best student presentation in pure mathematics

Subject prizes for applied mathematics

- The Australian and New Zealand Industrial and Applied Mathematics (ANZIAM) prize for the best student presentation in applied mathematics

Subject prizes for pure and applied statistics

- The New Zealand Statistical Association (NZSA) prize for the best student presentation in statistics

Subject prizes for data science

- Dragonfly Data Science prize for the best student presentation in data science

1.7 Social events

Tuesday 28th: Casual Math Crafts

For anyone who has arrived, we'll be having a casual math crafting session feat. Hexaflexagons by Grace. This will begin at 7pm in TTR205 at Victoria University Kelburn Campus (map here), however, feel free to show up any time after 7pm.

Wednesday 29th: Main social event at Counter Culture

A complementary social event will be held at Counter Culture on Wednesday 29th from 6pm to 9pm. Counter Culture is a board game cafe and bar on Victoria Street. It is an 11 minute walk from Trek. Food will be provided at this event, however, drinks will not be.

Thursday 30th: NZMASP roundtable

A roundtable discussion on the future of the NZMASP conference will be held at 7:00 pm on Thursday in RHMZ03 (Rutherford House, 33 Bunny Street, Pipitea, Wellington 6011). A map of Pipitea campus can be found here.

Friday 1st: Prize-giving

Will feature the awards ceremony, in which the conference organisers will thank the sponsors and plenary speakers and present prizes for outstanding student presentations. We will also hand over the reigns of the NZMASP conference to next year's Massey University-based committee. This will be held in RHMZ03 (Rutherford House, 33 Bunny Street, Pipitea, Wellington 6011) with special guest Kate Kolich.

Photos

Feel free to add any photos of your time at NZMASP 2023 to our shared Google Photos album available at this link.

A conference group photo will be taken outside the Royal Society.

Chapter 2

Programme

Wednesday 29th

Start	End	Presenter	Title	Chair
8:40	9:00	Committee	Opening remarks & safety etc	Malcolm Jones
9:00	9:20	Sam Bastida	The Mathematics of Juggling	Matt Slattery-Holmes
9:20	9:30	Sapir Ben-Shahar	Hexaflexagons	
9:30	9:50	Đorđe Mitrović	Some Conditions Implying Stability of Graphs	
9:50	10:10	Shai Levin	A Gentle Introduction to Zero-Knowledge Proofs	
10:10	10:30	Morning Tea		
10:30	11:30	Geertrui Van de Voorde	Plenary Talk	Sam Bastida
11:30	11:40	Break		
11:40	12:00	Rox-Anne L'Italien-Bruneau	From undergraduate studies to research in mathematics: towards the study of a rarely discussed transition	Sapir Ben-Shahar
12:00	12:20	Sang Hyun Kim	A Roadmap to Sensemaking: Developing an Instrument to Explore Mathematical Sensemaking Modes	
12:20	12:40	Sophia Witham	Mathematics of Poetry in Ancient India	
12:40	13:20	Lunch		
13:20	14:20	Sinapi Taeao and Robin Averill	Tu'utu'u le upega i le loloto - cast the net into deeper waters: Teaching Mathematics through Dance.	Ellen Hammatt
14:20	14:30	Break		
14:30	14:50	John Bailie	Navigating the North Atlantic's Mood Swings: A Tale of Density and Dynamics	Indranil Ghosh
14:50	15:10	Renzo Mancini De Barbieri	Temporal Feedback Mechanisms in the Atlantic Meridional Overturning Circulation: A Delay-Differential Equation Approach	
15:10	15:30	Afternoon tea		
15:30	15:50	Samuel Bolduc-St-Aubin	The effects of asymmetry and state-dependence in a delay differential equation model of the El Niño-Southern Oscillation	Daniel Wrench
15:50	16:10	Louis Davis	A Fractional Earthquake Model for a Fraction of the Data	
16:10	16:20	Broden Bishop	Linking multiple breast cancer datasets for disease progression models	
18:00	21:00		Counter Culture	

Thursday 30th

Room 1

Start	End	Presenter	Title	Chair
8:40	9:40	Lauren Smith	Plenary Talk	Shonaugh Wright
9:40	10:00	Morning tea		
10:00	10:20	Daniel Wrench	Using statistics to get wind of the Sun	Zac Isaac
10:20	10:40	Mark Bishop	Constraining solar wind transport model parameters using Bayesian analysis	
10:40	11:00	Jago Edyvean	The Effect of Scale Separation on Plasma Turbulence Simulations	
11:00	11:10	Break		
11:10	11:30	Davide Papapicco	Deep learning techniques for slow Kolmogorov n-width decay: a reduced order modelling perspective for non-linear advection equations	Lydia Turley
11:30	11:50	Zac Isaac	Abdominal dimmer switch: modelling the effect of adipose tissue on light presented to the human fetus using Monte Carlo simulations	
11:50	12:10	Paco Castaneda Ruan	Exploring competing Calcium oscillation patterns in lymphocytes.	
12:10	12:50	Lunch		
12:50	13:10	Lydia Turley	Modelling the genetic structure of fungal populations	Paco Castaneda Ruan
13:10	13:30	Satoshi Komuro	"Epidemic, Infodemic, and its Interplay: Spreading Processes on Networks"	
13:30	13:50	David Groothuizen Dijkema	Heteroclinic networks and travelling waves in spatially-extended models of cyclic competition	
13:50	14:00	Break		
14:00	14:20	Kate Truman	Identifiability of Phylogenetic Models	Ruofei Xie
14:20	14:40	Deborah Kakis	Trends in Statistical Methods in Medical Studies (2000 – 2023)	
14:40	15:00	Mashfiqul Huq Chowdhury	Variational Autoencoder Model for Representation Learning and Clustering	
15:00	15:20	Afternoon tea		
15:20	15:40	Abigail Edwards	Directing Undirected Phylogenetic Networks	Timotheus Keanu
15:40	16:00	Matt Slattery-Holmes	Pattern avoidance in the peak subalgebra of the quasisymmetric functions.	
16:00	16:20	Joshua Bardwell	Modules for Coxeter systems in general-type	
19:00	20:00		Round table	

Room 2

Start	End	Presenter	Title	Chair
11:10	11:30	Liam MacDonald	'Multi'-Directional search methods	David Groothuizen Dijkema
11:30	11:50	Thirumalai Vaasan Raghunathan	Separating safe and failure domain when a building is subjected to an earthquake	
11:50	12:10	Lennart Golks	Implementation of a linear-Gaussian hierarchical Bayesian model aiming to sample Ozone in the Atmosphere using a LIMB sounder	
12:10	12:50	Lunch		
12:50	13:10	Juan Patino-Echeverria	Beyond Classical Chaos: The Organising Centre of a Four-Dimensional Lorenz-Like System	Jago Edyvean
13:10	13:30	Indranil Ghosh	Understanding the Topology of Chaotic Attractors for Piecewise-Linear Maps using Renormalisation.	
13:30	13:50	Sam Doak	Invariant Manifolds: Organising Wild Chaos in a Discrete-Time Dynamical System	
13:50	14:00	Break		
14:00	14:20	Morganna Nickless	Fourier Analysis & Bandpass Filtering	Mark Bishop
14:20	14:40	Ryan Cox	Nested Sampling of Galaxy Clusters: A Practical Example of Bayesian Inference	
14:40	15:00			
15:00	15:20	Afternoon tea		
15:20	15:40	Kang Wang	Semi-parametric model fitting cluster gas pressure profile	Mark Bishop
15:40	16:00	Amin Boumerdassi	Using Convolutional Autoencoders for Signal Detection of Extreme Mass Ratio Inspirals Detected by the LISA Mission	
16:00	16:20	Tarin Eccleston	GANs for Core-Collapse Supernovae	
19:00	20:00		Round table	

Friday 1st

Start	End	Presenter	Title	Chair
8:40	9:40	Charlotte Jones-Todd	Plenary Talk	Laia Egea-Cortés
9:40	10:00	Morning tea		
10:00	10:10	Pooja Baburaj	Data requirements and challenges of observational urban data for the causal analysis	Asheel Ramanlal
10:10	10:30	Angeline Xiao	Parallel Queues with Time Delay	
10:30	10:50	Laia Egea-Cortés	Partial Ordered Stereotype Model Development of a New Model	
10:50	11:00	Break		
11:00	11:20	Nuwan Weeraratne	The Hole of Principal Component Analysis when fewer observations than dimensions	Malcolm Jones
11:20	11:40	Reza Siar	LDA Topic Modelling: Uncovering Coherent Topics of Hazara Genocide Campaign on Twitter	
11:40	12:10	Michell Shamu and Gabriel Pan	RBNZ talk	
12:10	12:50	Lunch	"RBNZ Networking with Michell Shamu, Gabriel Pan, Daniel Bins, Grace Lingyu Li and Kiran Malik"	
12:50	13:10	Darius Young	"Symmetries, surfaces and solubility"	Shai Levin
13:10	13:30	Stuart Teisseire	Conformal geometry and the Lichnerowicz conjecture	
13:30	13:50	Bradley Windelborn	Characterising Functions between Compact Connected Metric Spaces	
13:50	14:10	Timotheus Keanu	Mordell-Weil Groups over Elliptic Curves	
14:10	14:20	Break		
14:20	14:40	Ben Wilks	Time-domain scattering on an infinite guitar string	Ollie Markwell
14:40	15:00	Breanna Camden	Colliding non-linear gravitational and electromagnetic plane waves in plane symmetry	
15:00	15:20	Afternoon tea		
15:20	15:40	Merlyn Barrer	The asymptotic initial value problem for gravitational wave scattering	Ben Wilks
15:40	16:00	Ollie Markwell	The Generalised Conformal Field equations near spatial infinity	
16:00	16:20	Committee	Closing remarks	
16:30	18:00		Voting and Presentation of Prizes by Kate Kolich	

Chapter 3

Abstracts

3.1 Student speakers

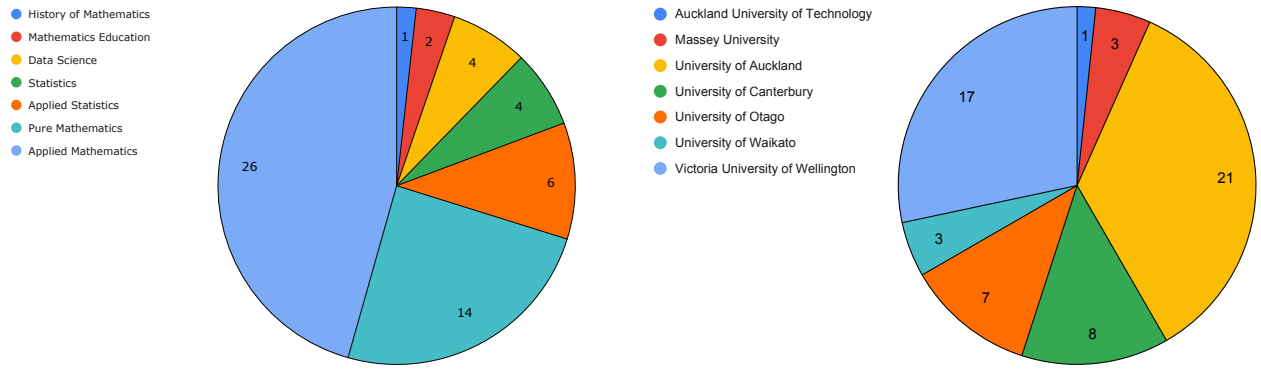

Figure 3.1: Stats for stats nerds

3.1.1 Applied Mathematics

John Bailie: *Navigating the North Atlantic's Mood Swings: A Tale of Density and Dynamics*
The Atlantic Meridional Overturning Circulation (AMOC) comprises warm surface currents that transport heat and salt to the North Atlantic and deep return currents that transport this water back southward. There is substantial evidence that the AMOC has been slowing down over the past decade, a trend that is worsened by the influx of freshwater from the melting Greenland Ice Sheets. We investigate a conceptual ocean model inspired by Welander, consisting of two vertically stacked boxes representing the surface layer and deep ocean in the North Atlantic. This model describes the evolution of temperature and salinity in the surface box, which is governed by convective and non-convective mixing processes with the deep ocean box.

We use bifurcation theory to characterize self-sustaining density oscillations in the surface box and demonstrate that they evolve locally on slow and fast time scales. Specifically, large influxes of meltwater may lead to long periods where the density is insufficient to sustain a convective mixing regime. Finally, we establish that a longer switching time between convective and non-convective mixing events may lead to the absence of self-sustaining oscillations.

Merlyn Barrer: *The initial value problem on past null infinity*
Einstein's theory of general relativity tells us that it is possible for massive objects to produce ripples in spacetime called gravitational waves, whose existence has been experimentally verified. In physics, an excellent way to gain insight into the behaviour of any wavelike object is through a scattering problem, where two incident waves interact with each other to produce new waves of a different shape. My work is part of a larger project to numerically solve the scattering problem for gravitational waves.

My work is in the prescription of the initial data on past null infinity, the area of the spacetime where the gravitational waves originate in the infinite past. A process called 'conformal compactification' is used which rescales the infinite spacetime to a finite region while preserving the important structure. This makes the problem more tractable, bringing infinity (where the initial data is prescribed) to a finite 'distance'. Given an initial waveform, a part of Einstein's equations called the Bianchi identity must be solved to obtain the remaining initial data on past

null infinity. I present some preliminary results for the linearised case.

Mark Bishop: *Constraining solar wind transport model parameters using Bayesian analysis*
Charged particles are ejected from the sun and transported radially outward, to the edge of the solar system, this plasma is called the solar wind. In the solar wind, turbulent fluctuations and waves form, and their transport can be modelled using the magnetohydrodynamic (MHD) equations. This modelling requires the inclusion of nonlinear phenomenologies, and turbulence source driving terms which have ambiguity in their strengths. The choice of free parameters in these terms have typically been estimated by relying on a family of conservation laws to provide analytical relations, or by analzing simulations. So far, solar wind turbulent transport studies have relied on these estimations, or generated 'best-fitting' values based on guess-and-check, and then by-eye validated the optimal model against in-situ solar wind observations. We introduce the use of Bayesian analysis (via nested sampling) for constraining the free parameters, and for comparing different models.

Samuel Bolduc-St-Aubin: *The effects of asymmetry and state-dependence in a delay differential equation model of the El Niño-Southern Oscillation*
The El Niño-Southern Oscillation (ENSO) system is a fluctuation in the temperature of sea surface waters in the eastern equatorial Pacific Ocean and in the surface air pressure between the eastern and western tropical Pacific Ocean. Delay differential equations have been used in the past to study the ENSO phenomenon. These conceptual models generally consist of a delayed negative feedback term and a nonautonomous periodic forcing. Despite their simplicity, recent studies have demonstrated that these models produce rich dynamical behaviour, even more so in the non constant delays case.

We consider a more complete description of ENSO by introducing and increasing state dependence in the delays and the asymmetry of the coupling function. We then conduct a bifurcation analysis by means of continuation software in order to understand these two additional model features.

Breanna Camden: *Colliding non-linear gravitational and electromagnetic plane waves in plane symmetry*
We use numerical methods to study the collisions of gravitational and electromagnetic plane waves, in vacuum in plane symmetry, in a fully non-linear general relativistic regime. The Einstein-Maxwell field equations are derived in the Newman-Penrose formalism and formulated as an initial boundary value problem under the Friedrich-Nagy gauge. We implement the Python package COFFEE to evolve this system for a range of boundary conditions using a fourth order method. Impulsive and Heaviside boundary data allows us compare our results to analytic solutions, such as the Bell-Szekeres model.

Paco Castaneda Ruan: *Exploring competing Calcium oscillation patterns in lymphocytes.*
Across the spectrum of cell types, the concentration of calcium controls a wide array of cellular functions. These calcium signals, usually in the form of periodic oscillations, play a paramount role in correct cellular activity. Lymphocytes, a type of white blood cell, are fundamental to the correct behaviour of the immune system and have been shown to exhibit two types of calcium oscillatory patterns under different conditions. This has led to the theory that these cells are equipped with two different, but interacting, signalling mechanisms. To study this theory, I will introduce a simple differential equation model, show that it can reproduce the two oscillatory patterns, show how this model can help us to understand the behaviours of our cells, and talk about some of the mathematical challenges that arise when trying to explain the oscillations.

Ryan Cox: *Nested Sampling of Galaxy Clusters: A Practical Example of Bayesian Inference*
Nested Sampling is a technique for Bayesian inference, commonly used in astrophysics. It handles likelihood evaluation and multimodal posteriors better than the more common Markov Chain Monte Carlo methods. I introduce nested sampling and illustrate its use in a real scenario with X-ray observations of galaxy clusters.

Sam Doak: *Invariant Manifolds: Organising Wild Chaos in a Discrete-Time Dynamical System*
In the 20th century the field of nonlinear dynamics was completely revolutionised by the discovery of a new kind of behaviour - chaos. This shocked researchers by demonstrating how unpredictability can arise in completely deterministic systems.

Over the last 30 years chaos has gotten even worse, in particular, a new kind of chaos - wild chaos - has entered the playing field. This chaos requires a sufficiently high dimensional system to occur, but when it does it is characterised by its staying-power - or robustness in the presence of small changes to the system.

So how can we organise chaos in order to study it? Our approach is to uncover the geometric structures underlying the dynamics - the so-called skeleton of the system. This consists of the system's equilibria in addition to trajectories that either move toward or away from these equilibria as time passes. The set of all points along these attracting or repelling trajectories form curves which are called the stable and unstable invariant manifolds.

In this talk, I'll provide an introduction to the theory of invariant manifolds and demonstrate the advanced numerical techniques used for calculating them. Furthermore, we'll compute these manifolds in a particular system to

observe some of the truly bizarre behaviour that makes up wild chaos.

Jago Edyvean: *The Effect of Scale Separation on Plasma Turbulence Simulations*
Turbulent plasma systems often require numerical simulations to investigate. Simulations can be fully fluid, fully kinetic, or a hybrid of the two. Choosing the best simulation to use will be ideally dictated by the plasma system, and problem, of interest. However, this simulation of choice may be highly computationally expensive. For example, investigating the sub-ion scale energetics of a collisionless plasma developing into, and undergoing turbulence, requires the resolution of the energy contacting scale as well as electron scale dynamics. The resolution of electron scale dynamics requires a certain grid coarseness. The system being collisionless, also requires a simulation with a high 'kineticity'. In such cases, computational cost is therefore often minimised by using artificial system parameters. One such parameter is the mass of the ions. This can be quantified by taking the ratio of ion to electron mass, the 'mass ratio'. My work looks to investigate the effects on the energetics of a turbulent collisionless plasma system due to simulating using artificial 'mass ratios'.

Indranil Ghosh: *Understanding the Topology of Chaotic Attractors for Piecewise-Linear Maps using Renormalisation*.
The two-dimensional border-collision normal form is a family of piecewise-linear maps with a highly complex bifurcation structure that remains to be fully demystified. It exhibits robust chaos throughout open regions of four-dimensional parameter space. In this talk I will show how the technique of renormalisation can be used to understand bifurcations of the topology (number of connected components) of the attractor in the robust chaos parameter region, where the map can be orientation-preserving, orientation-reversing, or non-invertible, and some effort is required to accommodate all three cases. Broadly speaking, renormalisation involves showing that, for some member of a family of maps, a higher iterate or induced map is conjugate to a different member of this family. However, this approach does miss some bifurcations, so I will also describe an algorithm for determining the number of connected components numerically.

David Groothuizen Dijkema: *Heteroclinic networks and travelling waves in spatially-extended models of cyclic competition*
A heteroclinic cycle is a structure in a dynamical system composed of a sequence of equilibria and orbits connecting them in a cyclic manner; a heteroclinic network is the connected union of heteroclinic cycles. Heteroclinic cycles and networks can be used to model intransitive competition between three or more species. For well-mixed populations, a system of ordinary differential equations will model these interactions, but the inclusion of diffusion terms allows the model to capture the spatial distribution and mobility of species. In one spatial dimension, we can observe travelling wave solutions which bifurcate from a heteroclinic structure. For three species in cyclic competition, this structure remains a heteroclinic cycle, the topology of which is preserved from the well-mixed model. However, with four or more species in cyclic competition, the heteroclinic cycle in the well-mixed system becomes a heteroclinic network, with additional orbits between equilibria. These new orbits allow for the formation of new types of travelling waves, corresponding to defensive alliances between subsets of species which suppress their respective competitors, and which can have configurations not possible in the well-mixed model.

Zac Isaac: *Abdominal dimmer switch: modelling the effect of adipose tissue on light presented to the human fetus using Monte Carlo simulations*
The extent to which external transdermal light sources illuminate the uterine environment is unknown. Recent experimental work indicates that the human fetus responds to external visual stimuli such as laser diodes, and initial modelling work suggests the fetus may not develop in a completely dark environment as previously assumed. Development of the human visual system begins within the womb, and there is motivation in fields such as developmental psychology, transabdominal oximetry, and photoacoustics to explore the extent to which light penetrates maternal abdominal tissue and how this varies with adipose thickness. In this talk, we outline a purpose-built Monte Carlo model that uses third trimester histological properties of maternal tissue in simulating transdermal monochromatic point light sources applied to the maternal abdomen. We use the results of this modelling to determine approximate levels of third trimester uterine illumination from such stimuli, discuss the scope for multiple stimuli to be visibly distinct in utero, and consider the extensions of this work to natural light and the ambient illuminance of the womb.

Satoshi Komuro: *Epidemic, Infodemic, and its Interplay: Spreading Processes on Networks*
Network science is a versatile and fascinating field of study, although it remains relatively underrepresented. In this talk, I will highlight key concepts and discoveries in network science. In the latter part, I will introduce our project, which aims to investigate the dynamic interplay between disease transmission and the dissemination of disease-related information from a network perspective.

Liam MacDonald: *Multi-Directional search methods*
We are minimizing the strongly convex quadratic function. Which search directions make good choices for minimizing

this function? We show that if the gradient is chosen as one of the search directions, then we get convergence. We also have the much stronger result of finite termination when a certain second direction is chosen too.

Renzo Mancini De Barbieri: *Temporal Feedback Mechanisms in the Atlantic Meridional Overturning Circulation: A Delay-Differential Equation Approach*
We theoretically study the Atlantic Meridional Overturning Circulation (AMOC) by means of a mathematical model with two-time delays. The time delays are associated with the positive temperature feedback between the Equator and the North Pole and the salinity exchange between the surface and deep water at the pole. Studying the interplay between these delayed feedback mechanisms conceptually can improve our understanding of the long-term dynamics and possible responses of the Atlantic Ocean.

The study employs a scalar delay differential equation integrating the two feedback loops. The focus is directed towards a comprehensive numerical bifurcation analysis conducted using the DDE-Biftool software package in Matlab. The investigation delves deeply into the distribution of homoclinic bifurcations, emphasizing their role in the organization of stable solutions within the system.

Ollie Markwell: *The Generalised Conformal Field equations near spatial infinity*
With the recent detections of gravitational wave signals by LIGO and Virgo, the behaviour of gravitational waves is of more interest than ever. The behaviour of these waves is governed by Einstein's field equations, a system of non-linear PDEs. Due to the non-linearity of these equations, exact analytic solutions are often not possible for even relatively simple physical situations, requiring the application of numerical techniques to solve them. This is complicated by the fact that we are interested in the behaviour of the waves at an infinite physical distance. In order to overcome this, Friedrich developed the Conformal Field Equations, which provide an extension of the Einstein equations to include a boundary at infinity. These can be reduced to a system of evolution equations which are hyperbolic, and so can be numerically integrated simply. However, they lose hyperbolicity at the cylinder corresponding to spatial infinity, which causes difficulties with numerical evolution. Overcoming these difficulties is essential in order to enable a full global evolution of a gravitational wave.

Morganna Nickless: *Fourier Analysis & Bandpass Filtering*
Fourier transforms play an important role in the filtering of frequencies and wavelengths, or in fact any periodic phenomena. By transforming these inputs, we interpret the information in terms of their frequencies or length scales, often called the frequency-domain or k-space. Multiplying this transformed information with some function, such as a Gaussian, before inverting the transformation, allows us to focus our analysis on only particular frequencies or length scales. This method is known as bandpass filtering and has many applications from audio control to vortex structures in magnetohydrodynamics - the study of electrically-charged fluids and my main area of research.

Davide Papapicco: *Deep learning techniques for slow Kolmogorov n-width decay: a reduced order modelling perspective for non-linear advection equations*
Models with dominant advection always posed a difficult challenge for projection-based reduced order modelling. Many methodologies that have recently been proposed are based on the pre-processing of the full-order solutions to accelerate the Kolmogorov nwidth decay thereby obtaining smaller linear subspaces with improved accuracy. These methods however must rely on the knowledge of the characteristic speeds in phase space of the solution, limiting their range of applicability to problems with explicit functional form for the advection field. Innovative techinques in deep learning however can be exploited to construct a framework for non-liner manifold reduction. In particular, the problem of automatically detecting the correct pre-processing transformation in a statistical learning framework is explored. A purely data-driven method may thus guide us to generalise the existing approaches of linear subspace manipulation to non-linear hyperbolic problems with unknown advection fields.

Juan Patino-Echeverria: *Beyond Classical Chaos: The Organising Centre of a Four-Dimensional Lorenz-Like System*
This talk explores the concept of wild chaos—a form of higher-dimensional chaotic dynamics that can only arise in vector fields of dimension at least four. In this talk, I will focus on understanding the geometric origins of a wild chaotic attractor in a four-dimensional Lorenz-like vector field. I will explain how a new spiralling feature around the origin in this system alters the dynamics inherent to the classic Lorenz equations.

Central to this talk is examining two distinct trajectories that converge to the origin in backward time, known as the unstable manifold of the origin. These trajectories play an essential role in the emergence of the renowned Lorenz attractor and associated complicated dynamics in the classic case; I will explain using the so-called kneading diagram how the unstable manifold of the origin in the four-dimensional Lorenz-like system repeatedly moves around a pair of equilibria and how this kneading diagram provides insights into the regions where wild chaos may occur and highlights a specific point as an organising centre.

Lydia Turley: *Modelling the genetic structure of fungal populations*

Population geneticists work with highly structured data which is several steps removed from the processes they try to study. Models bridge the gap between this data and questions about population biology. The standard models do not well describe fungi. I have developed a model specific to fungi. In this talk I describe my model, how it compares to the standard models, and how it can be applied in population biology.

Thirumalai Vaasan Raghunathan: *Separating safe and failure domain when a building is subject to an earthquake*
When a building is subjected to an earthquake, only two cases can happen: either the building is safe or the building collapses. There are some conditions for the building to be safe and some conditions for the building to collapse (failure). We want a 'boundary' that separates the safe and failure domain. Consider a section of a building, modelled as a block suspended on a base of springs (elastic foundation) which are tied together by means of a cable[1]. When the block is subjected to an earthquake, that is modelled as an in-plane sinusoidal forcing, the block tilts and responses as a damped oscillator. If the contact angle between the base of the block and the elastic foundation becomes too large, the cable breaks and the block falls of, which is equivalent to building collapse. It is crucial to define a safe domain where the block remains in contact with the elastic foundation. The safe domain here is the contact angle lying within a design limit state.A solution can 'graze' the design limit state with zero angular velocity at a particular time instant such that the contact angle lies within the safe domain at all previous times. A solution can graze either 'left' or 'right' because of symmetry in the system. As grazing can happen at any time instant, we get different grazing curves that grazes after different time periods of forcing. The'grazing curves' can act as a 'boundary' that separates the safe and failure domain. Along with the grazing curves, we have taken into consideration the invariant manifolds and these grazing curves interact with the manifolds which will be explained in detail in the talk.

Ben Wilks: *Time-domain scattering on an infinite guitar string*
Wave scattering on a infinite one-dimensional string, which is governed by the wave equation, is an useful prototype of acoustic wave and water wave scattering problems, which typically take place in unbounded domains. In this talk, we consider the time domain scattering problem. Our tool for solving it is the generalised eigenfunction expansion method, which works by diagonalising the time-evolution operator. The resulting eigenfunctions are single-frequency solutions—precisely those that arise from solving the corresponding frequency domain problem with a sinusoidal incident wave. We show the advantages of this method over integral transforms. Some cool animations will be shown at the end.

Daniel Wrench: *Using statistics to get wind of the Sun*
The solar wind is a turbulent fluid of charged particles that permeates the solar system. During its outward flow it carries a magnetic field, coronal mass ejections, and as-yet poorly understood physics about energy dissipation. Spectral statistics such as power spectra, correlation functions, and structure functions, calculated from time series, provide crucial insights into the behaviour of this (and many other) systems across scales. A widespread challenge in their utilization is data gaps, which afflict various domains in which measurements cannot be collected continuously. For example, our only in situ measurements from outside the solar system are spoilt by gaps from telemetry drop-outs and instrument malfunctions on board the Voyager spacecraft. This affects important analyses such as estimating the bandwidth of the so-called "energy cascade" of turbulence using the Reynolds number. I will delve into some interesting techniques for addressing this problem and maximising scientific return.

3.1.2 Pure Mathematics

Joshua Bardwell: *Structural properties of Bruhat interval modules*
Bruhat interval modules were recently introduced to study the 0-Hecke modules associated to many families of quasisymmetric functions. We extend the Bruhat interval modules, previously defined in type A, to all finite Coxeter types, and determine various structural properties of these modules. In particular, we provide an indecomposability criterion, and determine projective covers and injective hulls for significant classes of Bruhat interval modules. Our work simplifies and extends results in the literature for the modules associated to several important bases for the ring of quasisymmetric functions.

Sam Bastida: *The Mathematics of Juggling*
A mathematical model of juggling, known nowadays as site swaps, was developed around 1985 independently by groups in both the United States and United Kingdom. In this model numbers are assigned to the common throws jugglers use and a sequence of such numbers describes a juggling pattern or site swap. Not all site swaps are valid and the sequences that are valid correspond to affine permutations which are relevant for the construction of affine symmetric groups. In this talk I will discuss some of the mathematical ideas behind site swaps as well as exploring the various ways they have been extended to apply to different juggling tricks, I will also give some live demonstrations.

Sapir Ben-Shahar: *Hexaflexagons*
Come along for an interactive session on the mathematics of Hexaflexagons. Hexaflexagons are paper folding toys, where 'flexing' reveals a new side. Learn how to navigate through the layers of your hexaflexagons, whether they have 3, 6, 12, 24, or even more sides! If you have your own hexaflexagons, bring them along - limited hexaflexagons will be provided.

Abigail Edwards: *Directing Undirected Phylogenetic Networks*
A phylogenetic network is a type of digraph used to represent the evolutionary histories of species. We examine undirected phylogenetic networks, with a focus on level-2 networks. In particular we consider the problem of directing undirected networks to be tree-child. We give a characterization of which networks permit a tree-child directing, and give an outline for an algorithm to produce such directings.

Timotheus Keanu: *Mordell-Weil Groups over Elliptic Curves*
Elliptic curves is a type of algebraic curves that has many applications in number theory due to its arithmetic nature. They have lots of interesting properties. For example, the Mordell-Weil theorem tell us that an elliptic curve over the rational numbers is a finitely generated abelian group. In this talk, we will explore this result in more detail and discuss the challenges faced in the current research.

Shai Levin: *A Beginner's Guide to Zero Knowledge Proofs via Sigma Protocols*
Zero-Knowledge Proofs (of Knowledge) are protocols between two parties - a prover, and a verifier - which convinces a verifier that, with overwhelming probability, a prover possesses knowledge of some secret information. It is 'zero knowledge' since, entropically, no information about the secret can be gleaned from the interaction. You might have encountered this explanation in the wild, but their formal definitions seemingly shed little light on what a zero-knowledge proof can or cannot achieve in applications.

In this short presentation, I aim to introduce, motivate and intuit the properties of zero-knowledge, and proof-of-knowledge in the context of Sigma protocols, the most elementary construction of such proof systems. Hopefully, in doing so, illuminating how cryptographic definitions successfully capture formal notions of security.

Đorđe Mitrović: *Some conditions implying stability of graphs*
For a connected, non-bipartite graph X, the problem of understanding the automorphism group of the direct product $X \times Y$, with Y bipartite, often reduces to the particular case $Y = K_2$. We call a graph X stable if $X \times K_2$ has the simplest possible automorphism group, that is, $Aut(X \times K_2)$ is isomorphic to $Aut(X) \times Aut(K_2)$. We discuss stability in the context of two broad families of graphs: graphs with every edge lying on a triangle and triangle-free graphs.

Matt Slattery-Holmes: *Pattern avoidance in the peak subalgebra of the quasisymmetric functions.*
Given a set of permutations Π, we let $\mathfrak{S}_n(\Pi)$ denote the set of permutations from $\mathfrak{S}_n$ which avoid every element of Π in the sense that no subset of a permutation is order-isomorphic to any element of Π. Given a subset P of $\{1, 2, \ldots n-1\}$ we call K_P the peak function indexed by P. These peak functions form an additive basis of the peak subalgebra of quasisymmetric functions, and there exist combinatorial formulas for the expansion of many well known quasisymmetric functions in terms of these, via tableau diagrams.

We examine the expansions of pattern avoiding peak functions, a generating function given by $\tilde{Q}_n(\Pi) = \sum_\sigma K_{peak(\sigma)}$ in terms of Schur-Q functions, where the sum is taken over all σ which avoid every $\pi \in \Pi$. We discuss the elegance found in these expansions, prove some preliminary results, and discuss the methods which we intend to employ going forward.

Stuart Teisseire: *Conformal geometry and the Lichnerowicz conjecture*
This talk gives an intuitive introduction to manifolds and conformal geometry, aimed at a general mathematical audience. The talk ends with an intuitive description of the Lichnerowicz conjecture, which relates the conformal group to an isometry group in the conformal class.

Bradley Windelborn: *Characterising Functions between Compact Connected Metric Spaces*
We consider the following question: When can an arbitrary function between sets be turned into a continuous function between compact connected metric spaces by adding metrics to the sets? We discuss our conjectured solution to this. We will focus on the bijective self-map case and through looking at examples build a classifying conjecture/theorem.

Darius Young: *Symmetries, surfaces and solubility*
In this talk we will introduce a class of highly symmetric tilings of surfaces called regular maps. Regular maps arise as quotients of hyperbolic space and have both rich algebraic and geometric structure. We will define regular maps and their automorphism groups, and give many examples of where they arise, without delving too far into the technical details. We will finish with a discussion of a still open conjecture about the relative abundance of soluble vs insoluble regular maps, as well as an explanation of some recent progress made towards answering it.

3.1.3 Statistics

Laia Egea-Cortés: *Partial Ordered Stereotype Model Development of a New Model*
Ordinal data is prevalent across various fields. Nevertheless, even today, researchers often employ methods designed for continuous or nominal data to analyse ordinal response variables.It is important to notice that ordinal data is truly different in nature than continuous and nominal. Although each level is greater than the previous one, we can not, a priori, quantify the size of the difference on a numerical scale, and nor can we assume that the levels are equally spaced.The Proportional Odds Model Version of the Cumulative Logit Model is the most used ordinal model. Nevertheless, to use it, the data must satisfy the proportional odds assumption. In contrast, the Ordered Stereotype Model (OSM) includes score parameters which specify the potentially unequal distances between adjacent response categories. The OSM is a good alternative when the proportional odds assumption is not satisfied. The score parameters show the discriminating power of the covariates, that is, how well the covariates of the model can distinguish between response categories.It can, however, be the case that two covariates have different discriminating powers. My talk presents the Partial Ordered Stereotype Model (POSM) developed in my thesis, which is an extension of the OSM that allows different sets of score parameters within the same model.In this way, this new model captures the particularities of each covariate in terms of their discriminating power.To demonstrate the utility of this new model, we apply it to real-world salmon data. Our objective is to identify variables impacting salmon health and assess how these variables differentiate between health levels. Finally, a simulation study comparing the performance of the OSM and the POSM has been set up to identify the scenarios where one outperforms the other.

Deborah Kakis: *Trends in Statistical Methods in Medical Studies (2000 – 2023)*
Statistical analysis plays a significant role in medicine and healthcare research and practice. Having a command of statistics enables health professionals to be able to read, understand and synthesize published results to inform practice. Furthermore, it also allows those involved in research to be able to implement appropriate study designs, acquire quality data, and analyse it, to ensure reliability of findings. While it is desirable for health for health professionals to acquire a certain level of statistical competency, it is also important to know the type of statistical methods and skills that they will need to function in their various roles. Statistics, like many other disciplines, is constantly evolving and the same is true for the types of statistical methods and analyses used in medical and health sciences research. In this talk I will investigate statistical tools and methodologies applied in medical and health studies, enabling an understanding of the trends and patterns in use over the last twenty years. Abstract of articles published in the New England Journal of Medicine (NEJM) between 2000 – 2023 were analysed to identify and visualize the trend and prevalence of statistical methods and tools. This presentation shares preliminary findings that while descriptive and inferential statistics are still being widely used, more involved statistical procedures such as various regression models, multivariate analyses and machine learning models are making an appearance in recent years. These results contribute to the wider theme of a PhD research study that seeks to investigate the statistical literacy of health professionals in Papua New Guinea. An understanding of the trend in the types of statistics applied in medical and health studies will guide the development of a tool to assess the statistical literacy of health professionals. Further, it will provide insights to designing appropriate intervention strategies to improve statistical literacy of health professionals in Papua New Guinea.

Nuwan Weeraratne: *The Hole of Principal Component Analysis when fewer observations than dimensions*
The principal component analysis (PCA) is a statistical method that quantifies the relationship between each variable using the covariance matrices, evaluates the direction of the distribution of the data using the eigenvectors, and evaluates the relative significance of those directions using the eigenvalues. But, when $n < p$ high dimensional settings, as the usual covariance estimator does not converge to the true covariance matrix, standard PCA performs poorly. In this study, inspired by a fundamental issue associated with mean estimation when $n < p$, we propose a novel method to estimate the covariance through increasing the sample size by taking all the pairwise differences in the sample observations, instead of increasing sample size. Using pairwise differences simplifies the estimation of covariance for any distribution, as it does not require the estimation of the μ. In simulation experiments we demonstrate typically small, but persistent improvements in the estimation of principal components versus known ground truth, with respect to the angular separation between the population and sample principal components (PCs).

Angeline Xiao: *Parallel Queues with Time Delay*
The research aims to explore the effects of information delay on parallel queues for different dispatching methods. We will consider the problem of the optimal dispatching policy for dispatching to a pair of parallel queues with Markov service. We investigate the impact of the amount of information delay for queues with both synchronous and asynchronous updates and the influence of different service rates. Our research utilizes simulation methods in R to assess the efficiency of these policies.

3.1.4 Applied Statistics

Pooja Baburaj: *Data requirements and challenges of observational urban data for the causal analysis*
In causal analysis with observational data, meeting essential data requirements is paramount, including comprehensive covariate information, precise treatment/exposure data, reliable outcomes, an adequate sample size, temporal ordering, data quality, a control group, and addressing data-level mismatches. To address these challenges, resolving data-level mismatch challenges involves preprocessing, harmonization, and statistical techniques. Transparent reporting and collaboration with experts enhance validity. Understanding model assumptions and conducting sensitivity analysis are vital for robust causal inferences, ensuring more accurate and reliable urban causal analysis.

Broden Bishop: *Linking multiple breast cancer datasets for disease progression models*
Constructing a disease progression model for breast cancer screening requires a data set containing information about screening and disease history. There is currently no data set that contains all the required information and timelines for the New Zealand population. We have created a data set by combining data sourced from five New Zealand administrative health collections; New Zealand Cancer Registry, Te Rēhita Mate Ūtaetae Breast Cancer Foundation National Register, BreastScreen Aotearoa, National Maternity Collection and the Mortality Collection. Linking these sources has not been simple with issues of missing data, timeline inconsistencies, and differing temporal resolutions. Another data extract is expected to resolve the missing data issues. We anticipate that the final data set will be limited due to time resolutions with some assumptions accounting for timeline inconsistencies.

Louis Davis: *A Fractional Earthquake Model for a Fraction of the Data*
Unanimously successful seismic forecasts have evaded the scientific community for well over 50 years. While there are many reasons why, a major factor hindering analysis is missing data. During large events there is no way to distinguish the smaller earthquakes from noise and so data sets miss thousands of events. A previous point process model of ours, using ideas from fractional calculus applied to viscoelasticity, has been shown to effectively model earthquake sequences but does not explain this missing data. We have extended our model so that it factors in these missing events, dependent on the entire history of the process. Numerical efficiency problems have arisen and so we also refine a new promising parameter estimation method that is computationally faster than maximum likelihood.

Lennart Golks: *Implementation of a linear-Gaussian hierarchical Bayesian model aiming to sample Ozone in the Atmosphere using a LIMB sounder*
In this presentation, I would like to introduce the Marginal and Then Conditional (MTC) sampler applied on a linear-Gaussian hierarchical Bayesian model to recover the Ozone profile of a LIMB sounder. We set up a hierarchically ordered Bayesian model using ideas from spatial statistics along with commonly used Markov Chain Monte Carlo methods. The hyper-parameters describe the noise of the data and the smoothness of the parameters, in this case, the Ozone profile. Given some data, we can estimate the distribution over these unknown quantities, which in Bayesian statistics is commonly known as the posterior distribution. We aim to sample from the posterior distribution and use a Monte-Carlo estimate of the posterior by generating an ergodic Markov chain. In doing so, we marginalize the posterior distribution of the hierarchical Bayesian model first to generate hyperparameter samples. Then we condition on those hyper-parameters to generate samples from the full conditional of the parameters, e. g. the Ozone profile, given a specific measurement. At this stage, we simulate data according to a high-frequency sounder on the LIMB of the Atmosphere with known ground truth Ozone values and some white noise. We compare our Results to an established sampling algorithm, namely the t-walk algorithm.

Mashfiqul Huq Chowdhury: *Variational Autoencoder Model for Representation Learning and Clustering*
The variational inference method aims to approximate the posterior probabil-ity distribution through optimization in latent variable models. The variationalautoencoder (VAE) is a deep learning-based probabilistic model, which uses thevariational Bayes framework to capture the complex probability distribution ofhigh-dimensional unlabelled datasets. This model maximizes the evidence lowerbound instead of the log marginal likelihood and can learn smooth latent spacethrough regularization. The VAE model can generate effective latent embeddings,which can be used as downstream tasks such as clustering. We will demonstratethe results of the VAE model in terms of clustering performance and generatingnew samples based on high-dimensional datasets.

Kang Wang: *Semi-parametric nodal approach to estimate the cluster pressure profile*
The study aims to enhance the modelling of galaxy cluster gas profiles by employing a semi-parametric nodal approach. Traditional methods, such as the generalised Navarro–Frenk–White (gNFW) model, often suffer from parameter degeneracy, compromising their ability to accurately fit cluster profiles. Our node-based method introduces a flexible framework that precisely delineates the gas pressure profile of a cluster. Utilising data from the Planck space telescope pertaining to the Coma cluster, our model demonstrates a significant improvement in flexibility when compared to the gNFW model, particularly in defining the pressure-radius relationship. Through Bayesian analysis, an optimal structure comprising five nodes was determined for the cluster pressure profile in Coma region . The further research

should addresses three pivotal objectives to advance the modelling of galaxy cluster profiles: (1) developing a model with greater flexibility than the gNFW to improve profile fitting and mitigate the issue of parameter degeneracy; (2) implementing DNest 4 and Reversible Jump methodologies to facilitate multidimensional model selection, enhancing efficiency by obviating the need for repeated Bayesian factor comparisons; and (3) constructing an asymmetric model to more accurately capture the intricacies of galaxy cluster pressure profiles.

3.1.5 Data Science

Amin Boumerdassi: *Using Convolutional Autoencoders for Signal Detection of Extreme Mass Ratio Inspirals Detected by the LISA Mission*
Extreme Mass Ratio Inspirals (EMRIs) are gravitational wave (GW) events produced by the mergers of pairs of massive objects such as black holes and neutron stars whose mass ratio is $>$10,000. These GWs cause the distance between points in space to oscillate, and these oscillations are measured through the varying time of travel for laser light. Traditionally, the detection of GW events was performed through matched filtering in which a detected signal would be compared to millions of variations of a template model for a given type of GW event. In the case of EMRIs, this is computationally unfeasible owing to the huge parameter space of EMRI waveform models, years-long waveform duration, and large file size. My work attempts to overcome these problems by training a convolutional autoencoder on rapidly generated simulated EMRI signals. By framing this as an anomaly detection problem (anomaly = not an EMRI), the autoencoder attempts to reproduce EMRIs as accurately as possible by mapping the signal to a low dimensional representation and back to the original dimensionality. The successful autoencoder will accurately reconstruct EMRIs, poorly reconstruct anything else, and perform all this with little computational requirement.

Tarin Eccleston: *GANs for Core-Collapse Supernovae*
This research investigates generative models, particularly Deep Convolutional Generative Adversarial Networks (DCGANs), to expedite the generation of gravitational wave signals originating from core-collapse supernovae (CCSN). Current methods of generating such signals rely on complex interplay between general relativity, nuclear physics and particle physics, leading to simulations that often take months to complete. In contrast, this study demonstrates the efficiency of DCGANs in emulating these signals by learning the underlying distribution in the signal data.

Having a generative model conditioned on CCSN parameters allows us to create different combinations of parameters to generate new signals, representing a generalised set of potential CCSN gravitational wave forms that are vastly different from the limited training data. The generalised would allow other researchers to test and enhance state-of-the-art detection and parameter estimation schemes. Furthermore, the methodologies elucidated in this research can be extended to generate signals originating from diverse gravitational wave-producing phenomena.

Reza Siar: *LDA Topic Modelling: Uncovering Coherent Topics of Hazara Genocide Campaign on Twitter*
The Hazaras have suffered various kinds of atrocities over the past few centuries, which have escalated in recent years. Seeking justice and protection, they launched a Twitter campaign. The campaign mobilized millions of people around the world to tweet the hashtag. The researcher used topic modelling techniques to find the latent topics hidden in the corpus. Ten topics were identified as a baseline and then, after a significant optimisation and evaluation process, 17 topics were identified with their respective coherence scores. Some further work needed to be done, including monthly or daily variations and trends in the topics, comparison of more techniques and more criteria in evaluating the topics.

Kate Truman: *Identifiability of Phylogenetic Models*
I'll discuss the model identifiability issue that's been making waves in phylogenetics circles over the last few years and explain why the results of thousands of existing papers were called into question by a 2020 paper in Nature. A focus on the Fossilised-Birth-Death model will help to justify the continued inference of evolutionary rates from phylogenetic trees. I'll cover the differences between two essential phylogenetic tree types, and highlight how simple re-parameterisation of evolutionary rates holds the key to investigating identifiability.

3.1.6 Other

Sang Hyun Kim: *A Roadmap to Sensemaking: Developing an Instrument to Explore Mathematical Sensemaking Modes*
Sensemaking in mathematics is a prevalent element in all levels of mathematics education. It is widely recognised that students engage in various activities to help them make sense of the mathematics they encounter. Much of the existing literature manages to successfully describe sensemaking phenomena qualitatively rather than quantifying this aspect of student learning. This research utilises a framework centred around three distinct yet related modes of sensemaking: explanation, visualisation, and enactment. I will describe this framework and outline the process

of designing an instrument to measure students' perceived use of various activities as mathematics learners. The preliminary confirmatory factor analysis suggests that the data from a pilot study supports the assumptions of the generative learning framework. I discuss ways this work can be further expanded to help us understand the relationships between various modes of activities in one's problem-solving endeavours.

Rox-Anne L'Italien-Bruneau: *From undergraduate studies to research in mathematics: towards the study of a rarely discussed transition*
When introduced to research mathematics through summer projects or graduate studies, students must transform their mathematical ways of doing to align with the ones accepted in the professional mathematics community. The transition from undergraduate studies to research in mathematics, a relatively unexplored research area, is at the heart of the study discussed here. In my presentation, I share preliminary results from the analysis of a series of interviews with a mathematics graduate student who offered multiple stories about their adjustments to research mathematics. Building on commognition as an analytical framework, I illustrate the roles of learners' agency as part of the transition to research, and I characterise students' mathematical communication.

Sophia Witham: *Mathematics of Poetry in Ancient India*
While the 11th century Arabic text 'Al-Bīrūnī's India' on Indian science, customs, values, and religions has been studied extensively, the chapter titled 'Their Grammatical and Metrical Literature' on metrical verse has not. Metrical verse, and its study, is a significant part of Indian culture and tradition as it facilitates reliable oral transmission of knowledge. Ancient Indian poets undertook mathematically rigorous studies of metres, aiming to construct, identify, and calculate the number of theoretically possible metres dependent on specific rules. These poets' works are early examples of binary numbers and combinatorics.

I have made a detailed study of the mathematics of metrical verse discussed in Al-Bīrūnī's chapter on grammatical and metrical literature as well as studied Al-Bīrūnī's attempts to describe these to his Arabic literate audience. I also consider the broader historical significance of the transmission of this knowledge by a foreigner. This presentation provides a concise overview of Sanskrit metrical verse and addresses problems in the study of metrical verse discussed by Al-Bīrūnī's, specifically those which use binary numbers and combinatorics.

3.2 Plenary Speakers

Geertrui Van de Voorde
Geertrui Van de Voorde is a pure mathematician. Her primary research interests lie in finite geometry, an area within combinatorics. Her research mostly deals with interesting substructures within finite projective spaces. What makes these point sets interesting is their intersection properties, the groups acting on them, and/or their links with problems from finite field theory, coding theory, or graph theory.

She got her PhD at Ghent University, Belgium, in 2010. In 2017, after taking up postdoctoral positions at VUB (Free University Brussels) and Ghent University, she moved to New Zealand in 2017 to start as a lecturer at University of Canterbury.

Lauren Smith
Lauren Smith completed her BSc, MSc and PhD at Monash University in Melbourne, Australia. From there she held postdoc positions at Northwestern University and the University of Sydney as well as working briefly at the CSIRO (the Australian Government Research Organisation). Her first postdoc used piecewise isometry theory to study mixing in granular flows. In her second postdoc she developed model reduction methods for networks of coupled oscillators. She joined the Department of Mathematics at the University of Auckland in 2021.

Charlotte Jones-Todd
I am a statistician by trade and spend my working days researching and teaching statistics. My research focus is on spatial statistics; modelling the patterns and movements of events in space and over time. When teaching I love finding new ways to get everybody as enthusiastic about stats as I am!

Outside of work, I spend most of my time running around after my pets. I have a Hungarian Vizsla puppy called Cai. I am also an avid horse lover. I have a horse, Nymph, who I enjoy trail riding and a Shetland pony called Norna, who is her best friend.

3.3 Industry Speakers

Michell Shamu and Gabriel Pan
Michell graduated in Economics and a minor in Actuarial Science from Victoria University of Wellington and currently works at the Reserve Bank of New Zealand as a Statistical Analyst in the Data, Statistics and Analytics Department. She enjoys working with numbers and providing insights in a way that is intriguing and engaging, communication is also one of her interests.

Outside of work, she spends her time learning new African dances as a way to keep in touch with her culture and enjoy being in nature which is very abundant in New Zealand.

Gabriel Pan is a graduate analyst at Te Pūtea Matua, working in the Deposit Taker Statistics team. He primarily works with mortgage statistics - in particular, he looks at the amount of risky lending a bank is doing as a proportion of its mortgage commitments and compare various borrower groups during a given reference time period. He also works with the Data Development and Policy teams to develop frameworks for banks around this higher risk lending.

Gabriel is a relative newbie at the bank (and to Wellington!) - he only joined in February, having just completed his masters at the start of 2023 at the University of Canterbury.

3.4 Guest Speakers

Robin Averill
Associate Professor Robin Averill works in mathematics education and initial teacher education at Te Herenga Waka-Victoria University of Wellington. Robin is an experienced secondary school mathematics teacher who has worked with academics, postgraduate students, student teachers, and teachers. She has carried out research in culturally sustaining education and mathematics education and published extensively . Robin is particularly keen on people having enticing, energising, and powerful experiences of learning and achievement in mathematics and statistics.

Sinapi Taeao
Sinapi hails from the beautiful island of Samoa. She is a Deputy Principal at Sacred Heart College, Lower Hutt. She teaches Mathematics and Statistics, Religious Studies, Gagana Samoa and Japanese to all year levels. She is part of the NZQA Taupulega Pacific advisory group, established to progress and achieve the goals of the NZQA action plan for pacific learner success, Takiala Pasifika 2020-2023. Sinapi holds a Master of Education from Te Herenga Waka Victoria University of Wellington, and is co-author of an article titled "'Tu'utu'u le upega i le loloto - cast the net into deeper waters': using research and practice to rethink mathematics pedagogy"

3.5 Special Guest

Kate Kolich- Assistant Governor/General Manager Information Data and Analytics from the Reserve Bank of New Zealand
Kate is the Assistant Governor/General Manager Information, Data and Analytics at Reserve Bank of New Zealand. Kate has an extensive career in digital, data and technology leadership roles across the public and private sectors. Her experience includes almost 20 years in financial services including at Bank of New Zealand where she held a number of data leadership roles including Head of Enterprise Data and Information Services.

In her time at BNZ, Kate led many strategic data initiatives and teams across the bank. Prior to joining the RBNZ, Kate led the Evidence, Insights and Innovation team at EECA (Energy Efficiency and Conservation Authority). Prior to that, she was the Director of Data Systems and Analytics at the Social Wellbeing Agency. Kate is passionate about supporting continued education and was a member of the Victoria University of Wellington Human Ethics Committee for a number of years. She was also previously a member of the MIT Sloan CISR Data Research contributing to industry data research.

As a recognised thought leader on digital and data innovation, Kate is active in promoting women in STEM through her work as a Global Women in Data Science Ambassador where Kate has been instrumental in bringing the Women in Data Science to New Zealand conference to New Zealand at both University of Auckland and Victoria University of Wellington and is a member of the Women in Data Science Worldwide Advisory Council.

Kate has a Bachelor of Arts degree and a Master of Information Management in Information Systems from Victoria University of Wellington. She also holds an Executive Certificate in Strategy and Innovation from Massachusetts Institute of Technology Sloan School of Management.

Chapter 4

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The Reserve Bank of New Zealand is New Zealand's central bank. They are primarily a policy organization and exist to promote a sound and dynamic monetary and financial system. For graduate opportunities, see their website.

Wolfram Research

Founded by Stephen Wolfram in 1987, Wolfram Research is one of the world's most respected computer, web and cloud software companies—as well as a powerhouse of scientific and technical innovation. As a pioneer in computation and computational knowledge, they have pursued a long-term vision to develop the science, technology and tools to make computation an ever-more-potent force in today's and tomorrow's world. Visit their website to find out more.

The Department of Mathematics and Statistics, University of Wellington

Te Herenga Waka—Victoria University of Wellington is one of New Zealand's oldest and most prestigious tertiary institutions with a proud tradition of academic excellence. Visit their website to find out more.

The New Zealand Mathematical Society

The New Zealand Mathematical Society (Inc.) is the representative body of professional mathematicians in New Zealand, and was founded in 1974. Its aims include promotion of research in the mathematical sciences, the development, application and dissemination of mathematical knowledge within New Zealand, and effective cooperation and collaboration between mathematicians and their colleagues in New Zealand and in other countries.

The New Zealand Statistical Association

The NZ Statistical Association, founded in 1948, is New Zealand's only association for professional statisticians. For a fuller description of the aims and activities of the NZSA, and background to this page, visit their aims and activities page.

ANZIAM

ANZIAM (Australia and New Zealand Industrial and Applied Mathematics) is a division of The Australian Mathematical Society (AustMS). Their members are interested in applied mathematical research, mathematical applications in industry and business, and mathematics education at tertiary level. The New Zealand Branch of ANZIAM aims to promote Applied and Industrial Mathematics in New Zealand.

Dragonfly Data Science

Dragonfly Data Science are a team of scientists and dreamers based in Aotearoa New Zealand, with a shared purpose of doing good with data. Visit their website to find out more.

Harmonic Analytics

Harmonic Analytics is a leading data science company based in New Zealand. Visit their website to find out more.

New Zealand Institute of Physics

The New Zealand Institute of Physics is the institute for professional physicists. Our members include college teachers, university lecturers, students studying to be physicists, CRI scientists, industry scientists, etc. Visit their website to find out more.

Te Pūnaha Matatini

Te Pūnaha Matatini – the meeting place of many faces – is the Aotearoa New Zealand Centre of Research Excellence for complex systems. Visit their website to find out more.

Chapter 5

Code of Conduct

All participants in the NZMASP 2023 conference are required to agree to the code of conduct as a condition of registration.

The NZMASP organising committee is committed to a professional, open, productive, and respectful exchange of ideas. These aims require a community and environment that fosters inclusion, provides mutual respect, and embraces diversity.

The NZMASP conference is dedicated to providing a harassment-free conference experience for everyone, regardless of gender, gender identity and expression, sexual orientation, disability, physical appearance, body size, race, age or religion. We do not tolerate harassment of conference participants or staff in any form.

Conference participants violating these rules may be sanctioned or expelled from the conference without a refund at the discretion of the conference organisers.

Harassment includes, but is not limited to:

- Verbal comments that reinforce social structures of domination related to gender, gender identity and expression, sexual orientation, disability, physical appearance, body size, race, age or religion.
- Sexual images in public spaces
- Deliberate intimidation, stalking, or following
- Harassing photography or recording
- Sustained disruption of presentations or other events
- Inappropriate physical contact
- Unwelcome sexual attention
- Advocating for, or encouraging, any of the above behaviour

5.1 Enforcement

Participants asked to stop any harassing behaviour are expected to comply immediately. If a participant engages in harassing behaviour, event organisers retain the right to take any actions to keep the event a welcoming environment for all participants. This includes warning the offender or expulsion from the conference with no refund. Event organisers may take action to redress anything designed to, or with the clear intention of, disrupting the event or making the environment hostile for any participants. We expect participants to follow these rules for the duration of the conference, including at the conference venue, accommodation and all conference-related social activities.

5.2 Reporting

If someone makes you or anyone else feel unsafe or unwelcome, please report it as soon as possible. Harassment and other code of conduct violations reduce the value of our event for everyone. We want you to be happy at our event. People like you make our event a better place.

If you're not sure if something you have seen or experienced should be reported, please contact a member of the organising committee for an informal discussion on the issue using the contact details in the contact information section below. You can make a report either personally or anonymously.

5.2.1 Anonymous Report

You can make an anonymous report here We can't follow up an anonymous report with you directly, but we will fully investigate it and take whatever action is necessary to prevent a recurrence.

5.2.2 Personal Report

You can make a personal report by contacting a member of the organising committee in person or via the contact details listed in the contact information section below.

When taking a personal report, our committee members will ensure you are safe and cannot be overheard. They may involve other committee members to ensure your report is managed properly. Once safe, we'll ask you to tell us about what happened. This can be upsetting, but we'll handle it as respectfully as possible, and you can bring someone to support you. You won't be asked to confront anyone and we won't tell anyone who you are. We will consult you before taking any action based on your report. Our team will be happy to help you contact local law enforcement, local support services, provide escorts, or otherwise assist you to feel safe for the duration of the event. We value your attendance.

Chapter 6

Statement on diversity and equity

The New Zealand Mathematics and Statistics Postgraduate (NZMASP) conference intends to provide an open platform for all postgraduate students in mathematics and statistics to present their research and grow their collaborative networks; however, we recognize that these fields exhibit some of the lowest levels of diversity of gender, race and culture in academia. The organising committee for the 2023 NZMASP conference will seek to address these inequities based on the following guiding principles:

- While an ideal goal would be for the level of attendance of women, people with marginalised gender identities, people with disabilities and people from racial or cultural minorities to be representative of the New Zealand population as a whole, we acknowledge that this is currently unrealistic due to the historic and ongoing inequity in our field.
- Since we can't control who comes to the conference, our mission is to make the conference welcoming to all attendees, particularly if they identify with or belong to under-represented groups.

With this in mind, the NZMASP organising committee is addressing, and will address, these issues by:

- Establishing a good process for handling all forms of discrimination and harassment – please refer to our code of conduct for details,
- Regularly having discussions about cultural inclusion,
- Incorporating Maori language into conference addresses,
- Promoting the normalisation of women in STEM fields through the gender diversity of our invited speakers list,
- Bringing disabled access to the forefront of our planning efforts, particularly with regards to the conference venue and accommodation provider,
- Meeting the needs of attendees with disabilities that are not already catered for (such as the hearing impaired) on a flexible basis,
- Offering a variety of accommodation options which take people's preferences into account. In particular, while the primary mode of accommodation provided by the conference is shared, this can be adjusted to cater for different group and individual requirements,
- Offering support and flexible options for attendees travelling with children,
- Catering to a variety of dietary requirements including Kosher, Halal, vegan, vegetarian and food allergies.