# NEWSLETTER

OF THE

NEW ZEALAND MATHEMATICAL SOCIETY

# Contents

PUBLISHER'S NOTICE	2
EDITORIAL	3
PRESIDENT'S COLUMN	4
EDUCATION	5
$\pi$ -DAY: MATHS & ART COMPETITION AT UOA	6
PROFILE	9
LOCAL NEWS 1	12
PhD SUCCESS 1	18
<b>REPORTS ON EVENTS</b> 2	21
NZMS NOTICES	23

# **PUBLISHER'S NOTICE**

This newsletter is the official organ of the New Zealand Mathematical Society Inc. This issue was edited by Marie Graff and Florian Lehner. Editorial enquiries and items for submission to this journal should be submitted as plain text or LATEX files with "NZMS newsletter" in the title of the email to newsletter@nzmathsoc.org.nz. LATEX templates are available upon request from the editors.

The official address of the Society is:

The New Zealand Mathematical Society, c/- The Royal Society of New Zealand, P.O. Box 598, Wellington, New Zealand.

However, correspondence should normally be sent to the Secretary:

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#### NZMS Council and officers

PRESIDENT VICE PRESIDENT SECRETARY TREASURER COUNCILLORS Bernd Krauskopf Melissa Tacy Geertrui Van der Voorde Stephen Joe Francis Leslie-Ellis (2018–2026), Tammy Lynch (2019–2026), Dominic Searles (2020–2026), Dimitrios Mitsotakis (2021–2027), Jeroen Schillewaert (2021–2027), Brendan Harding (2023–2026).

#### Other positions of responsibility

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#### Web Sites

NZMS homepage: nzmathsoc.org.nz (Webmaster: david.bryant@otago.ac.nz) The newsletter is available at: nzmathsoc.org.nz/newsletter/ ISSN 0110-0025

# **EDITORIAL**

Kia ora koutou,

We hope that this Newsletter finds you in good spirits after the first teaching months. 2025 announces a small change in the editorial team: Florian Lehner is editing his first issue<sup>1</sup>.

In this issue you will find the welcome of the new president, on whom the profile is dedicated as well. The education column proposes a reflection on AI And how to adapt our teaching strategies. You will also enjoy some reports on activities:  $\pi$ -day competition at the University of Auckland, NZMRI summer meeting in Hanmer Springs in January 2025.

We are looking for more content to add in the future newsletters. If you have any ideas, please feel free to contact us to inquire or even send us your piece already written. We, the editors, cannot make this newsletter great without your input. We hope to make 2025 as exciting as the previous years. By the way, did you know that:

$$2025 = (20+25)^{2}$$

$$\sqrt{2025} = (2+0!)^{2} \times 5$$

$$2025 = (1+2+3+4+5+6+7+8+9)^{2}$$

$$2025 = 1^{3}+2^{3}+3^{3}+4^{3}+5^{3}+6^{3}+7^{3}+8^{3}+9^{3}$$

$$2025 = 1^{0}+2^{0}+\dots+2025^{0}$$

Marie Graff and Florian Lehner

<sup>&</sup>lt;sup>1</sup>Marie's note: Please join me to welcome him!

# **PRESIDENT'S COLUMN**

After the buzz of the Joint Meeting in December and the summer break, the first half of the semester has flown by... We are well into 2025 and I hope you are all having a good Easter break.

As you know, I have just taken over from Melissa Tacy as President of the NZMS, and this is my first Column. So I am still finding my feet and I would like to start by thanking Melissa for the tremendous amount of dedication and effort she put into the role of President and as Chair of the Joint Meeting. I am very happy that she is staying on as Vice President in 2025 according to our Constitution!

Talking about the Constitution, we are about to re-register and submit our revised document, and I would like to thank Stephen Joe for managing this process. His attention to detail on these matters are crucial in getting this right and, of course, this role is on top of Stephen's tasks as our Treasurer!

My thanks also to our Council members and, especially, to our Secretary Geertrui Van de Voorde. Thanks as well to Marie Graff and Chris Stevens for being the Editors of the Newsletter (and for pinging me to write this Column).

You may wonder what I have been doing as President myself so far. The answer is that things have been ramping up slowly after the summer break. Ongoing issues concern our involvement with the Save Science Coalition, and our representation, via the Royal Society Te Apārangi, as part of the International Mathematical Union.

Finally, I regret to announce that I won't be providing a ChatGPT Thriller version; of course, you are all welcome to put this Column into the AI tool of your choice and see what comes out...

All the best,

Bernd Krauskopf

# **EDUCATION**

#### **AI in Mathematics Education**

A couple of years ago people joked that they would now use chatGPT to write their grant reports. Since then, AI has made its presence felt in academia and educational institutions. AI bots can now do an undergraduate maths assignment. At the current rate of progress, we could soon be dealing with the possibility of them writing an honours or masters thesis.

The big issue with AI is around academic integrity. The possibility of using AI to cheat on assignments was one motivation for the change in assessment in our first year calculus course at Auckland (Maths 130), where weighting for assignments was moved to in-person supervised assessments: tutorial participation and invigilated tests.

#### **Generating problems**

AI has its challenges but is a very useful tool. Educators are already promoting the use of AI in Mathematics Education to generate rich mathematical tasks:

https://www.edutopia.org/article/using-ai-math-instruction/.

The focus of the above article is school-level maths instruction (in the US). How well would it work for universitylevel maths? I experimented with prompts of the form *Create a mathematics problem on [some mathematical concept] in the context of [some application].*<sup>2</sup>

**Prompt:** Create a mathematics problem that uses a differentiable but not continuously differentiable function in an engineering context.

AI output: In a mechanical damping system, the displacement y(t) of a vibrating mass is modelled by the function

$$y(t) = \begin{cases} t^2 \sin\left(\frac{1}{t}\right) & \text{if } t \neq 0, \\ 0 & \text{if } t = 0. \end{cases}$$

- (i) Show that y(t) is differentiable everywhere on  $\mathbb{R}$ , but its derivative y'(t) is *not* continuously differentiable at t = 0.
- (ii) The damping force opposing the motion is  $F_d(t) = -cy'(t)$ , where c > 0 is the damping coefficient. Compute the total work done by the damping force from t = -1 to t = 1. Recall that work done is  $W = \int_{-1}^{1} F_d(t) \cdot y'(t) dt$ .

In part (i) it would be more natural to show that y(t) itself is not continuously differentiable (rather than its derivative). Changing the function to

$$y(t) = \begin{cases} (1-t)^2 \sin\left(\frac{1}{1-t}\right) & \text{if } t < 1, \\ 0 & \text{if } t \ge 1. \end{cases}$$

would also make it look more physically natural. But it is not a function that would appear in any real-life model. Dispensing with part (ii) would avoid getting too deep into physics, and the integral to be computed in part (ii) is a very nasty expression that is impossible to do analytically.

Another prompt was: *Create a mathematics problem that illustrates Cauchy sequences in the context of economics.* The AI came up with a problem where the market price of some product satisfied some recurrence relation involving supply and demand, converging to some equilibrium.

In conclusion, AI does a good job at generating ideas for problems (at least, in undergraduate real analysis). It makes connections that teachers would not come up with on their own from scratch. Teachers can refine, correct, and further develop the problems.

<sup>&</sup>lt;sup>2</sup>I used the (free) Deepseek for Android.

# $\pi$ -DAY: MATHS & ART COMPETITION AT UOA

March 14<sup>th</sup> (3.14) is  $\pi$ -day, a symbolic date for us Mathematicians. To celebrate it, Nicolette and Jonny decided to organise a contest of the best art piece about mathematics at the University of Auckland. 2025 is the second issue of this contest, the premiere having been launched in 2024. Staff and students were invited to participate by submitting their artwork, which was displayed during a week and subject to votes.



Nicolette and Jonny at the event, in front of the winning piece.

This year, no less than thirteen wonderful entries have been presented with very diverse techniques: sculptures, drawings, collages... each depicting some mathematical concepts or situations.



Fractulus Fun by Beth Harford



*Tangent: Echos of*  $x^3 - 3x$  by Amber Garrett



Hazen's cube by Hazen



*CAT(0)* by Logan McDonald



*Apeirogon* by Ari Markowitz



Sixteen intersecting triangles by Claire Postlethwaite



Saddles of Love by Mahnoor Qadri



*Four intersecting planes* by Tianlang Gong



Clash of Titans – Irrational vs Imaginary by Cathy Kang

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Table of (Elementary) Algebras by Kevin Shen Su



*Life in the Complex Plane* by Aimee Lew



Eager First Year Student by Leo, Nick, V, Elliot, Ben and Nathan



*Tired Postgrad Student* by Leo, Nick, V, Elliot, Ben and Nathan

At the end of the voting period, congratulations and prizes were awarded to Leo, Nick, V, Elliot, Ben and Nathan for their work "Tired Postgrad Student".

Nicolette and Jonny plan to run this event again next year and hope to see even more entries!

Marie Graff

### PROFILE

#### **Bernd Krauskopf**



Dynamical systems are mathematical models of the time evolution of real systems, both natural and human, such as ecosystems, the Earth's weather and climate systems, neurons, lasers, electronic circuits and aircraft, to name but a few. These models are often process-based and can, therefore, be very powerful. For example, they can explain and predict new, often counter-intuitive, nonlinear phenomena of great importance for applications. Furthermore, such phenomena can be universal, bridging the gaps between different disciplines. Due to their nonlinearities and multiple scales, dynamical systems can be challenging to analyse. There are two distinct but complementary approaches to their analysis:

- (i) Rigorous qualitative theory, which provides insights into the behaviour of solutions without knowing them explicitly.
- (ii) Numerical methods developed to approximate the actual solutions.

Bernd Krauskopf's work pushes the boundaries of applied dynamical systems by combining these two approaches to develop new computational techniques for solving problems in applications that span many fields of science and engineering. In doing so, he has championed a new strand within the field of dynamical systems and made invaluable contributions that have had a significant impact worldwide.

Bernd started his career as a PhD student with Floris Takens at the University of Groningen in the Netherlands in 1991. The topic of his PhD research was suggested by none other than V. I. Arnold who posed the question: "What happens near a bifurcation where a closed orbit of a vector field loses stability in a 1:4 resonance?" Arnold and Takens had independently proposed a model in the form of a  $\mathbb{Z}_4$ -equivariant planar vector field, which Arnold claimed contained all versal unfoldings of such bifurcations. Takens probably had some ideas how to tackle this challenging conjecture, but neither he nor Arnold expected Bernd's novel approach, which involved not only numerical simulation, but the much more powerful tool of pseudo-arclength continuation using the software package AUTO<sup>3</sup> developed by Eusebius Doedel. Bernd was the first to use AUTO to compute bifurcation surfaces, rather

<sup>&</sup>lt;sup>3</sup>"AUTO-07P: Continuation and bifurcation software for ordinary differential equations," by E. J. Doedel and B. E. Oldeman (2007), with major contributions from A. R. Champneys, F. Dercole, T. F. Fairgrieve, Yu. A. Kuznetsov, R. C. Paffenroth, B. Sandstede, X. J. Wang, and C. H. Zhang; available from http://cmvl.cs.concordia.ca/auto

than curves, which started his drive to push computational methods to their design limits, and beyond if necessary. By combining these computational techniques, especially for the continuation of global bifurcations, with the analysis of a codimension-three singularity at  $\infty$ , Bernd was able to produce all known unfoldings in Arnold's model; while not a complete proof, he provided compelling evidence for the validity of Arnold's conjecture.

After his PhD, from 1995 to 1998, Bernd worked with John Guckenheimer at Cornell University in Ithaca, USA, and then with Daan Lenstra at the Vrije Universiteit Amsterdam in the Netherlands. It was during his time in Amsterdam that Bernd became fascinated by the nonlinear dynamics of semiconductor laser systems. This fascination was a turning point in his early scientific career. It led to some of the first bifurcation diagrams for lasers with saturable absorbers, optical injection and external optical feedback. This new approach attracted much attention in the laser dynamics community and led to a number of new collaborations. Of particular importance were Bernd's collaborations, unusual for a mathematician, with laser physicists working on real laser experiments to compare their measurements with theoretical predictions. Ultimately, Bernd has made original and internationally recognised research contributions in the area of laser instabilities and numerical bifurcation analysis of delay differential equations that arise naturally as mathematical models of such laser systems. Nonlinear photonics remains one of Bernd's main research interests.

Bernd's arrival in Bristol in 1998 marked a period of growth in dynamical systems research; he played a key role in establishing the Bristol Centre for Applied Nonlinear Mathematics and building the research culture within the department. He was often found in the open-plan research offices engaged in animated discussions with PhD students and postdocs. His collaborative work on delay differential equations and algorithms for computing true and slow invariant manifolds for dynamical systems provided two of the core scientific themes within the group. The influence of this work extended world-wide, driven in part by his meticulous attention to high-quality visualisations of the intricate dynamic phenomena encountered, such as the geometry of slow manifolds near a folded node. To this day, colleagues in Bristol still have memories<sup>4</sup> of Bernd bringing out a ruler to measure how well the different plots within a figure were aligned.

Over the years, Bernd's research interests expanded to include a wide range of engineering applications, with a particular focus on aircraft landing gear, wheel shimmy, and ground dynamics in collaboration with Airbus. From unearthing parameter combinations that created regions of tri-stability in the shimmy response of a landing gear to the discovery of a swallowtail catastrophe that governs the retraction operation of a novel landing gear concept, these works demonstrated the utility of computational methods that are at the core of Bernd's research. This demonstration led Airbus to adopt numerical continuation techniques to help them understand nonlinear phenomena that might arise in their future aircraft designs: phenomena such as the canard explosions in the ground handling behaviour of aircraft that Bernd's work discovered! Hybrid testing / real-time dynamic substructuring methods brought an impactful engineering and Physical Sciences Research Council (EPSRC) grant, which funded a significant number of postdocs. The development of control-based continuation techniques with Jan Sieber exemplifies his ability to bridge mathematics with experimental engineering, creating lasting impact in both fields.

When Bernd arrived at the University of Auckland in 2011, he immediately immersed himself in various novel projects, paving the way for new collaborations and cementing his commitment to training a new generation of researchers. His presence was felt from the onset, as he quickly became a driving force behind projects ranging from new techniques for computing slow manifolds and canard trajectories in slow-fast dynamical systems to the study of geometric structures associated with new types of chaotic behaviour. For the latter in particular, new techniques for the computation of heterodimensional cycles and blenders were developed, providing a bridge between theory and possible applications.

During this time, Bernd's research also continued to focus on nonlinear dynamics of optical systems and numerical bifurcation analysis of delay differential equations. His expertise in these areas, combined with his interdisciplinary approach, quickly positioned him as a member of the Dodd-Walls Centre for Photonics and Quantum Technologies, a New Zealand research centre of excellence. Here, he has worked on projects related to the modelling of pulse propagation in optical fibers, the analysis of semiclassical approximations of dissipative quantum systems, and the study of the emergence of exotic dynamical behaviours in these systems. These often intricate and complex phenomena have been elucidated by the theoretical and numerical techniques that Bernd and his collaborators have developed and refined throughout his career. This work has significantly advanced the understanding of both fundamental and applied aspects of nonlinear photonics.

On the occasion of his 60<sup>th</sup> birthday, we have asked several of Bernd's collaborators to contribute to a "Special Issue in Honour of Professor Bernd Krauskopf". The text for this profile is a reproduction of the foreword for

<sup>&</sup>lt;sup>4</sup>Some former PhD students might describe these as nightmares.

the special issue, which will appear as a Special Collection in *The ANZIAM Journal*. Once finalised, it will feature 11 papers, by authors with affiliations from nine different countries, on topics ranging from industrial dynamics, mathematical biology, electrical engineering, and laser physics, to the core mathematical questions of global bifurcations, dynamics with delays, grazing phenomena, and Poincaré embeddings.

Sebastian Wieczorek, Hinke M Osinga, James Knowles, Andrus Giraldo, and David A W Barton.

[This text is almost identical to the foreword for the "Special Collection in honour of Professor Bernd Krauskopf" that will appear soon; is has been reproduced with permission from *The ANZIAM Journal*.]

# LOCAL NEWS

#### AUCKLAND UNIVERSITY OF TECHNOLOGY

#### SCHOOL OF ENGINEERING, COMPUTER AND MATHEMATICAL SCIENCES

#### **New Colleagues**

*Dr Yik Ching (Josh) Lee* holds a Bachelor of Engineering (Honours) in Mechanical Engineering from Nanyang Technological University, a master's degree in biomedical engineering from Fachhochschule Furtwangen University, and a PhD in Bioengineering from the University of Auckland.

He was previously with AUT between 2019 and 2022, and rejoined the university in 2025 as a Lecturer in the Department of Mathematical Sciences within the School of Engineering, Computer and Mathematical Sciences.

Josh is a Fellow of the Higher Education Academy, and his research interest focuses on leveraging technology to enhance student agency and improve learning experiences in STEM education.

#### **Research and Study Leave**

Prof Jiling Cao is on Research and Study Leave (RSL) in the first half of 2025. During his RSL period, Dr Nuttanan Wichitaksorn is appointed as Acting Head of the Mathematical Sciences Department at AUT.

In March-April, Jiling visited four universities in China: Minnan Normal University, Tianjin University, Nankai University and Tiangong University. He presented several seminar talks at these universities on his recent research work and also undertake joint research on some projects with his Chinese collaborators.



Prof Jiling Cao is presenting a seminar talk at Tiangong University

Prof Sergei Gulyaev is on Research and Study Leave (RSL) in the first half of 2025.

#### **Conference attendance**

Dr. Parul Tiwari presented a research article entitled "Data-Driven Water Quality Modelling and Prediction for New Zealand Rivers: A Predictive Approach to Environmental Sustainability" in NZMS, AMS, AustMS Joint Conference held from 8-13 Dec. 2024 at University of Auckland.

Dr. Parul Tiwari presented a research article entitled "Meta modelling for Geometric Brownian Motion using Polynomial Chaos Method' Environmental Sustainability" in ANZIAM 2025 held from 02-06 Feb. 2025 at Coffs Harbour, NSW, Australia.

Dr. Hammed Fatoyinbo attended the Joint Meeting of the New Zealand Mathematical Society (NZMS), the Australian Mathematical Society (AustMS), and the American Mathematical Society (AMS) at the University of Auckland from December 9–13, 2024. He presented a talk on sero-epidemiological modelling of Infectious Bursal Disease in the Industrial Mathematics special session.



Dr Hammed Fatoyinbo is presenting his talk at the 2025 Joint Meeting

Undergraduate students from the School of Engineering, Computer, and Mathematical Sciences (SECMS) at Auckland University of Technology, coached by Dr. Hammed Fatoyinbo and Dr. Kerri Spooner, participated in the SCUDEM 2024 competition (challenge period: October 19 – November 12, 2024). SECMS had two teams, each consisting of three students. Both teams received the Meritorious Award. More information about SCUDEM can be found here https: //qubeshub.org/community/groups/scudem.

Dr. Kerri Spooner hosts the International Mathematical Modelling Challenge (IMMC) for secondary school students each year. Student teams of four members, select a five consecutive day period to work on each year's modelling challenge. Once all entries are received, the judges panel select the top two entries to represent New Zealand. Submissions are currently being received for consideration for selection for this year's New Zealand submission. New Zealand has been competing in the competition since 2016 and regularly has received top outstanding awards:

- 2022: St Andrew's College were one of the three outstanding international award winners.
- 2021: Mt Roskill Grammar where one of six teams to be awarded Meritorious.
- 2019: Manurewa High School were one of the five outstanding international award winners

https://www.tvnz.co.nz/shows/sevensharp/clips/manurewa-high-schoolstudents-work-out-how-many-humanscan-fit-on-the-planet

or

# https://www.facebook.com/sevensharp/videos/383512878970213.

• In 2016 Whangarei Boys High was also awarded Meritorious.

New Zealand teams also have regularly been given honourable mentions during the history of the challenge. See https://www.immchallenge.org/ Index.html for more details of the competition and past challenge questions.

#### Visitors



Dr Indranil Ghosh is presenting his talk at the MMARC seminar series

Dr. Indranil Ghosh, a Marsden Postdoctoral Fellow at Massey University in Palmerston, visited Dr. Hammed Fatoyinbo. He presented their research on Dynamical Properties of Neuron Models – Nodal and Collective Behaviours at the AUT Mathematical Modelling and Analytics Research Centre (MMARC) seminar series. The outcome of their research during this visit has recently been accepted for publication in Physical Review E.

https://journals.aps.org/pre/abstract/10. 1103/PhysRevE.111.044204

#### Seminars of the Mathematical Modelling and Analytics Research Centre

Dr Takafumi Kubota from Tama University, Japan, delivered a talk "Visualization of suicide death data and factor analysis of suicide ideation data" on 28th February 2025.

Wenjun Zhang

#### **UNIVERSITY OF AUCKLAND**

#### DEPARTMENT OF MATHEMATICS

#### Staff News

We were pleased to have two Inaugural Lectures in March:

- "Winnerless competition: dynamics of Rock-Paper-Scissors and other games" by Professor Claire Postlethwaite, and
- "Geometry, symmetry and a touch of magic" by Professor Jeroen Schillewaert.

More information about these lectures and recordings can be found at:

https://www.auckland.ac.nz/en/science/news-and-events/inaugural-lecture-series/past-lectures.html

Hinke Osinga is invited speaker at ICDEA 2025, the International Conference on Difference Equations and Applications (https://icdea2025.sciencesconf.org/) which will be held 15-19 July in Guangzhou, China.

Pedram Hekmati is visiting the Max Planck Institute for Mathematics in Bonn and the Institut des Hautes Etudes Scientifiques in Paris during his sabbatical in the first half of the year.

#### **Other News**

To help make the most of some overseas visitors, and the excellent efforts being made by Tanya Evans to promote evidence-based research in Maths Education, as well as the achievements of some PhD students soon to complete, Marston Conder organised a two-day workshop in the Maths Department on 11 and 12 February 2025, on "Algebra, Geometry and Education". Speakers and their talk titles and other details can be seen at

https://www.math.auckland.ac.nz/~conder/ PAGE-2025.html

The department hosted Richard B. Melrose (MIT) as the 2025 Erceg Visiting Fellow in the second half of February. Prof. Melrose is a highly influential differential geometer and analyst, known for solving several outstanding problems in diffraction theory and scattering theory and developing analytical tools that are being used extensively in these fields. Qiongling Li (Chern Insitute of Mathematics) also visited Auckland in February as the Kalman Visiting Fellow. The workshop "At the Interface of Geometry and Analysis" was organised in connection with their visit:

https://www.math.auckland.ac.nz/ hekmati/AG2025/

Kevin Coulembier, David Ridout and Pedram Hekmati are organising the conference "Algebra at Akaroa" in January 2026. The aim of this meeting is to bring together researchers with an interest in algebra and its applications to cultivate interactions and broaden toolkits. Such applications include, but are not limited to, category theory, geometry, number theory, representation theory and mathematical physics:

https://www.math.auckland.ac.nz/ hekmati/Akaroa2026/

The department hosted a number of visitors in the third quarter of the year, including

- Behrooz Yousefzadeh, (Concordia University)
- Jonathan Kress (UNSW)
- Edward Huang (National Cheng Kung University)
- Martin Liebeck (Imperial College, London)
- Melissa Lee (Monash University)
- Tomasz Popiel (Monash University)
- Ali Zaidi (LUMS University, Pakistan)
- Prof. Jozef Siran (Slovak University of Technology)
- Len Bos (University of Verona)
- Song Dai (Tianjin University)
- Sam Blitz (Masaryk University)
- Adam Thomas (University of Warwick)
- Clemens Dieter Puppe (Karlsruhe Institute of Technology)
- Rina Zazkis (Simon Fraser University)
- Madhavan Venkatesh (IIT Kanpu)

Pedram Hekmati

#### DEPARTMENT OF ENGINEERING SCIENCE AND BIOMEDICAL ENGINEERING

In February, the 3<sup>rd</sup> New Zealand Workshop on Uncertainty Quantification and Inverse Problems was organised by Ru Nicholson (ESB), Oliver Maclaren (ESB), Prasad Babarenda Gamage (Auckland Bioengineering Institute), and Tiangang Cui (University of Sydney). The workshop featured a plenary talk of Owen Dillon (University of Sydney) and presentations by Finbar Argus (Auckland Bioengineering Institute), Andreas Kempa-Liehr (ESB), Philipp Wacker (UoC), Dingchen Luo (University of Texas), Colin Fox (UoO), Erik Garcia Neefjes (Macquarie University), Nich Wright (ESB), and Lennart Golks (UoO). Many thanks to the organisation committee for this well balanced and relaxed workshop.

The department congratulates Dr Christina Yin-Chieh Lin, Dr Dale Emet Altar, and Fatemeh Esmaeili for successfully defending their PhD theses. Well done!

Andreas Kempa-Liehr

#### **UNIVERSITY OF WAIKATO**

#### DEPARTMENT OF MATHEMATICS AND STATISTICS

Preparations for the 2025 NZMS Colloquium are well underway. Nicholas Cavenagh is the Convenor of the Colloquium and it will take place at the Hamilton Campus from Wednesday, 26 November to Friday, 28 November. A separate notice about the Colloquium appears elsewhere in this Newsletter.

Tanvi Chandel has recently arrived to take up a continuing position as a Teaching Fellow in Data Analytics. In her studies at AUT, she completed a master's degree and has recently submitted her PhD thesis for examination. Her thesis is on the impact of blood pressure measurement error on cardiovascular disease risk prediction and management. This PhD work was supported by a scholarship from a MBIE Endeavour Smart Ideas grant. She has had previous work experience as a teaching assistant, healthcare analyst, and data scientist.

Te Ara Tatauranga — The Statistics Consulting Group was recently established in the School of Computing and Mathematical Sciences. This group consists of statistical consultants (Han Gan, Paul Brown, and Jason Kurz) and mathematical modelling consultants (Jacob Heerikhuisen, Sean Oughton, and Woei Chet Lim). The group's services and support are currently free for up to 4 hours per year for postgraduate students and staff at the University of Waikato. It will also provide external consultancy services. Those with long memories will recall that we used to have a Waikato Centre for Applied Statistics until 2009 which provided similar services.

Han is part of a recent Health Research Council Health Delivery Research Project to do with evaluating the equitable roll out of publicly-funded continuous glucose monitors for people with type 1 diabetes.

Stephen Joe

#### MASSEY UNIVERSITY

#### SCHOOL OF MATHEMATICAL AND COMPUTATIONAL SCIENCES

A number of staff including Indranil Ghosh, Carlo Laing, Tammy Lynch, David Simpson, Winston Sweatman, Chris Tuffley and Graeme Wake attended the joint meeting of the NZMS, AustMS and AMS, held in Auckland, December 9-13.

#### Seminar:

Dongxi Ye from Sun Yat-sen University, China, gave a seminar entitled "On Ramanujan-type series for  $1/\pi$ " on 20 January.

#### Links to Sri Lanka:

Emeritus Professor Graeme Wake was privileged to be one of the opening speakers (he had to be there only via Zoom, regrettably) at an international gathering in Columbo in early April, hosted by the Sri Lankan-NZ Friendship Forum (SNFF). It was chaired by Massey PhD graduate Senaratne Galkowite and is aimed to foster educational and scientific cooperation between Sri Lanka and New Zealand. They were particularly interested in the work done by an international team of us (convened by Graeme), under the auspices of the QECD, over 10 years on Industrial Mathematics (now beginning to be seen as more under the broader banner of "Analytics"). Graeme Wake was asked to outline this, as it had started in NZ, and our work in SE Asia and the western Pacific regions. The big successes are in South Korea and Thailand, where national clusters like MINZ (Mathematics-in-Industry for NZ) are now thriving. Our High Commissioner to Sri Lanka, David Pine, was a speaker later in the meeting. It is to be hoped that this sort of development may happen in Sri Lanka in the future.

Vice-Chancellor Professor Jan Thomas has given a year's notice of her resignation.

Carlo Laing

#### VICTORIA UNIVERSITY OF WELLINGTON

#### SCHOOL OF MATHEMATICS AND STATISTICS

The last period was relatively quiet, but we still have a few interesting pieces of news from Te Herenga Waka in Wellington:

As a result of the 2024 Faculty Realignment Project at Te Herenga Waka – Victoria University of Wellington, the Faculty of Science and the Faculty of Engineering have been merged into a single faculty. Consequently, the School of Mathematics and Statistics is now part of the newly formed Faculty of Science and Engineering. This structural change was accompanied by a leadership transition: Professor Ivy Liu has taken on the role of Head of School from Professor Lisa Orloff Clark, and will serve in this capacity until a new Head is appointed by the new faculty.

We are also pleased to announce that PhD Candidate Ruofei Xie defended successfully their PhD thesis under the supervision of Prof. Noam Greenberg and second supervisor Dr. Dan Turetsky. The title of Ruofei's PhD is "Computability, Randomness, and Analysis". Congratulations to Ruofei!

Dimitrios Mitsotakis

#### **UNIVERSITY OF CANTERBURY**

#### SCHOOL OF MATHEMATICS AND STATISTICS

During February 11-14, Charles Semple and Mike Steel hosted 'Kaikoura 2025' - the 28th annual New Zealand phylogenomics conference in Kaikoura. The annual meeting attracted 48 participants, both within NZ and from abroad, with students and academics from mathematics, statistics, data science, and biology coming together to discuss the latest developments in phylogenomics (the reconstruction of evolutionary trees and networks from genomic data). The series of 28 meetings started in Kaikoura in 1996, and has been held in various locations over the years. This year's meeting was held at Kaikoura's new Sudima hotel, as the University of Canterbury field station (where previous meetings there have been held) has now been demolished due to earthquake concerns.

CSSE and Maths and Stats held a pizza and choc course advice session to assist students with course questions prior to the semester enrolment date. The event helps guide students who may have identified concerns with their course selection in the first weeks of term.



Some of the participants at Kaikoura 2025 taking a morning break between talks.



Course advice session.

The school has developed a set on new high school posters designed to inspire students and connect these subjects with outcomes. These will be delivered to almost 400 schools around New Zealand, along with a link to our new Math199 which seeks to inspire students to join the course and experience UC during the course's midyear workshop. The Math199 video can be viewed here.

Michael Plank, FRSNZ has been elected as a Ngā Ahurei a Te Apārangi Fellow of the Royal Society Te Apārangi, a prestigious recognition of his outstanding contributions to the mathematical modelling of complex systems in biology and epidemiology. His work has had a profound impact, shaping our understanding of everything from ecological dynamics to pandemic responses.

PhD student Sebenele Thwala has had a her letter accepted in Physical Review Letters — one of the most prestigious journals in all of physics. Further, it has been flagged as an 'editor's suggestion', which are given to only around 1 in 6 letters.

Sebe's research explores the deep mysteries of gravitational waves — ripples in the fabric of space-time that



Michael Plank FRSNZ.

carry secrets from black holes, neutron stars, and the early universe.

To be published in Physical Review Letters while still completing a PhD is a remarkable achievement — and a testament to the originality, depth, and significance of Sebe's contributions so far. You can read the letter here.

Sebenele is supervised by Dr Chris Stevens (University of Canterbury) and Professor Jörg Frauendiener (University of Otago).



Sebenele Thwala and Chris Stevens.

MATH199, our university mathematics course for senior high school students, grew by 30% this year. Students from 117 schools across New Zealand are now engaging with university-level maths through the program. It continues to challenge and inspire, offering a strong foundation for future study. We're proud to support the next generation of mathematical thinkers from across the country. February saw 10 staff travel to 25 schools from Whangārei to Balclutha, setting students with the course and fostering relationships with maths departments.

Chris Stevens



MATH199 students.

#### **UNIVERSITY OF OTAGO**

#### DEPARTMENT OF MATHEMATICS AND STATISTICS

The annual Welcome Barbecue for students and staff, jointly hosted with the Department of Physics, took place on 25 February on the Clocktower Lawn. Despite an unpromising weather forecast, the skies held, and many students and staff took the opportunity to catch up over a free lunch. It was a great way to kick off the new academic year.

Congratulations to Matt Schofield on his out-of-season promotion to Professor, effective from 1 February 2025 — a very well-deserved recognition!

More good news: We warmly congratulate Tilman Davies and his wife Andrea on the birth of their daughter Saskia, who arrived on 4 March 2025. Both mother and baby are doing well. Best wishes to the whole family!



Tilman and Saskia

On 8 March, GeMS in STEM — a social group focusing on issues of equity and diversity in STEM subjects — hosted the annual International Women's Day Wikipedia edit-a-thon, led by dedicated volunteer editor Tamsin Braisher. Staff and students worked together to improve the visibility of women and genderminority mathematicians, statisticians, physicists, and related topics. More than 60 articles were edited, with over 70 references and 4,500 words added — really impressive work by all involved!

Jörg Hennig

# PhD SUCCESS

#### Christina Yin-Chieh Lin (University of Auckland. 2024)

**Title**: Predicting House Sale Prices in Newly Developed Suburbs Without Historical Sales. **Supervisors**: Andreas Kempa-Liehr and Andrew Mason (both University of Auckland)

#### Abstract:

There is a recent trend of housing developers designing masterplan suburbs based on new urbanist principles to solve the housing crisis all around the world. The aim of this study is to anticipate the value of housing features in recently developed suburbs using a Bayesian approach, and investigate the price premiums of masterplan suburbs in the Auckland housing market. We present the Standard House Configuration Model, where housing feature impacts are analyzed relative to the configuration of a standard house for easy interpretation. The benefit of using a Bayesian approach is that we describe housing feature impacts using highest density intervals, which more closely resemble the intuitive understanding of probability intervals than statistical confidence intervals. Our case study on the newly developed suburbs of Fairview Heights, Oteha, Stonefields, Long Bay, Flat Bush, Silverdale, and Hobsonville in Auckland, New Zealand, demonstrates that the posterior distributions from our model effectively capture the complex relationship between housing features and sale price (R2 value of 91.5%). From analyzing the seven newly developed suburbs in Auckland, New Zealand, we find evidence that masterplan suburbs have higher price premiums than traditional suburbs. Our model estimates that master- plan suburbs offer a 17.47% to 20.16% price premium compared to non-masterplan suburbs. The proposed model is cross-validated on four recently developed suburbs in Auckland. For comparable suburbs, our model is able to make reasonably accurate price predictions without using any historical sale records from the target suburb. This indicates that the insights into housing feature impacts are applicable to other new suburbs still in the planning stage and, therefore, have the potential to support future suburb developments.

#### Dale Emet Altar (University of Auckland. 2024)

**Title**: Reactive Transport Modelling of Flow Through Porous and Fractured Media in Geothermal Systems. **Supervisors**: Sadiq Zarrouk and Eylem Kaya (both University of Auckland)

#### Abstract:

This research uses reactive transport models (RTM) to analyse the hydrological, thermal, and chemical processes in hydrothermal environments, particularly geothermal systems. Comprehensive investigations reveal critical processes, challenges, and opportunities which enhance our understanding of hydrothermal systems. This research highlights RTM applications in experimental research, geothermal reservoir management and geological carbon dioxide storage.

The methodologies and results of representative fluid-rock interaction models under high temperature and pressure conditions extending to the supercritical regime are explained. Accuracy gaps in reaction parameters are addressed by validating models against experimental and operational data and through sensitivity analyses. The primary simulation tool used is TOUGHREACTTM, a non-isothermal multi-component reactive fluid flow and geochemical transport simulator.

This work begins through an in-depth review of existing research on RTM for geothermal applications, governing equations, and available tools. Specific transport and chemical interaction parameters and associated estimation methods are likewise explored.

The first numerical investigations focus on calibrated models for basalt-water interactions under subcritical and supercritical conditions. The usefulness of calibrated RTMs in capturing individual mineral reaction kinetics and equilibria in whole-rock experiments is demonstrated. Model utility in ascertaining the geochemical properties of whole rock samples and offering insights into alteration sequences is exhibited.

Next, a natural state model for a theoretical two-phase liquid-dominated geothermal reservoir was developed. Modelled mineral alterations and fluid chemistry are compared to analogous natural systems. Permeabilities are shown to evolve with mineral alteration. Orogenetic processes for ore metals, e.g., gold, are likewise simulated, revealing how they form in a geothermal reservoir.

The application of reservoir RTMs for CO2 sequestration was explored next. Through the use of simplified 1D radial models, it is shown that dissolved CO2 in reinjected brine changes fluid chemistry, promoting the formation of mineral dissolution and impeding permeability loss caused by mineral scaling.

Finally, a theoretical 3D liquid-dominated geothermal reservoir model provides a more comprehensive analysis of CO2 storage potential and reservoir impacts, exhibiting both dissolution and mineralisation trapping. It also reveals that CO2 injection may increase NCG content in produced steam over time through injection returns.

#### Fatemeh Esmaeili (University of Auckland. 2024)

**Title**: Automatic Detection and Quantification of Chemicals of Interest Utilizing Deep Learning Algorithms in Electrochemical Biosensors.

**Supervisors**: Alan Wang (University of Auckland), Natalie Plank (Victoria University Wellington), Charles Unsworth (University of Auckland)

#### Abstract:

Nanomaterial-based aptasensors are crucial for detecting small biological entities. Effective signal processing methods are essential for improving biosensor performance by enhancing the identification and quantification of target analytes. This thesis investigates signals from three electrochemical aptamer-based sensors, each featuring distinct receptors, analytes, and signal lengths.

The ultimate objective of this study is the automated detection and quantification of target analytes within the sensor-recorded signals, resembling a classification task. In order to achieve this objective, the thesis explores evolutionary pathways. The initial classification task involves identifying and quantifying specific analyte concentrations across six distinct classes, ranging from zero presence to 10  $\mu$ M. Subsequently, a second classification task was designed to differentiate abnormal from normal data segments, detecting the presence or absence of analytes in the sample. When detected, this task further aims to identify the specific analyte and quantify its concentration.

Data scarcity presented a significant challenge, necessitating the use of data augmentation techniques. An initial approach involved scaling data augmentation to address limited original data availability. Long short-term memory (LSTM) networks were utilized for analyte concentration prediction, with systematic variations for fine-tuning in network configuration and data augmentation quantity showing notable impact on model performance.

Consequently, building upon the findings from the previous step, an automatic anomaly detection method, utilizing autoencoder-based prediction models, was introduced in a semisupervised learning approach. Autoencoder networks and kernel density estimation (KDE) helped detect anomalies, although uncertainties persist regarding segment length's impact on model performance.

In the concluding phase, a data augmentation technique using conditional variational autoencoders was introduced to address data scarcity within deep learning algorithms. Recurrent-based networks were developed for signal extrapolation to ensure consistent signal lengths, and short-term Fourier transform (STFT) preprocessing was explored. Seven deep learning classification models (GRU, unidirectional LSTM (ULSTM), bidirectional LSTM (BLSTM), ConvGRU, ConvULSTM, ConvBLSTM, and CNN) were developed, demonstrating the effectiveness of preprocessing methods in improving neural network performance for analyte identification and quantification.

Overall, this study contributes to automated analyte detection and quantification using aptasensors, offering practical data augmentation methods, signal reconstruction, and insights into unknown datasets. The introduced classification model provides inspiration for novel methodologies.

Ruofei Xie (Victoria University of Wellington. 2024)

**Title**: Computability, Randomness, and Analysis. **Supervisors**: Noam Greenberg, Dan Turetsky (both Victoria University Wellington)

#### Abstract:

We study computability theory in three different contexts. Firstly, we study the relationship between PA degrees and Martin-Löf randomness. In particular, we focus on nonuniformity of the PA degrees computed from optimal c.e. supermartingales. Secondly, we investigate Rademacher series  $\sum x_n a_n$ , where  $x_n \in \{-1,1\}^{\infty}$  and  $(a_n)$  is a sequence of square-summable reals. On the one hand, to ensure that the sum converges for any computable  $(a_n)$ , we ask how random x should be. On the other hand, we study the class of x which makes the sum converge, and compare it with other randomness notions. Lastly, we explore computability theory in analysis, especially, the complexity of the collection of Banach spaces that have the local basis structure.

# **REPORTS ON EVENTS**

### New Zealand Mathematics Research Institute Annual Summer Workshop 2025

The NZMRI (New Zealand Mathematics Research Institute) was established by Vaughan Jones and others with the aim of promoting mathematical research in New Zealand. Since 1994 the main focus of the NZMRI's activity has been the organisation of an annual series of summer meetings on particular topics of contemporary significance in mathematics. The meetings have a pleasant and informal atmosphere.

This year's NZMRI Summer Workshop was held from January 13th to 17th, 2025, in Hanmer Springs, focusing on the theme "Wave Propagation Phenomena: Theory and Computations". The invited speakers were a distinguished and diverse group of five academics who explored various aspects of wave propagation, ranging from theoretical to practical applications and from modern advancements to classical perspectives. The five invited speakers were:

- Hongqiu Chen (University of Memphis, USA): Theory of nonlinear waves
- Eldad Haber (University of British Columbia, Canada): Neural networks for inverse scattering problems
- Stuart Hawkins (MacQuarie University, Australia): Computational methods for multiple scattering
- Emily Lane (NIWA, New Zealand): Applications to tsunami
- Paul Martin (Colorado School of Mines, USA): Theory of multiple wave scattering





Figure 1: Participants (left panel) – Speakers (right panel)

In addition, the NZMRI meeting had the pleasure of hosting two renowned guest speakers, each of whom delivered an introductory lecture: Prof. Jerry Bona (University of Illinois at Chicago, USA), introduced the audience to solitary waves, and Dr. Dionyssios Mantzavinos, (University of Kansas, USA), to linear and nonlinear dispersive wave equations.

Furthermore, two two-hour sessions featuring hands-on activities were held on Tuesday and Thursday afternoons, providing participants with practical, applied interactions with waves. Particularly, Dr. Stuart Hawkins proposed a challenge to focus numerically the wave intensity using multiple scatterers and Dr. Emily Lane created "human waves" where the participants played the role of particles.

The meeting was generally regarded as a great success, with full attendance and with over thirty participants for the entire week. The intriguing lectures and activities were designed by the speakers to introduce the audience into the fascinating and complicated world of waves. Tutorials were mostly attended by students, who really enjoyed the more practical interaction with waves. Captured below are moments from the conference, where speakers shared insights and attendees engaged in thought-provoking discussions and activities.

The organisers would like to thank the speakers and the participants, as well as the sponsors (NZMRI, the department of Mathematics of the University of Auckland, Fabien Montiel, and Marie Graff) for their generous support.





Figure 2: Students engaged with wave scattering (left panel) – Participants generating harmonics using a rope (right panel)

Further information and material from the lectures can be found on the website of the event: (https://sites.google.com/aucklanduni.ac.nz/nzmri2025).

The organisers, Fabien Montiel (University of Otago) Dimitrios Mitsotakis (Victoria University of Wellington) Marie Graff (University of Auckland).

# NZMS NOTICES

#### NZMS Colloquium 2025

The NZMS Colloquium 2025 will take place on the Hamilton campus of the University of Waikato from Wednesday, 26<sup>th</sup> November until Friday the 28<sup>th</sup> November, 2025. The conference opens at 9am on the Wednesday, but there will also be a welcome reception at the Pā; on campus from 5pm til 7pm on Tuesday, 25<sup>th</sup> November.

All talks will take place in S block and the conference dinner will be on the evening of Thursday, 27<sup>th</sup> November, in the Gallagher Academy of performing Arts, which is also on campus. As there is limited accommodation within walking distance of the campus, rooms will be available at the onsite campus college for \$95 per night. You will be able to book these rooms when you register. The Colloquium website, together with online registration, will appear in the near future.

Stephen Joe

#### NZMS Financial assistance

The NZ Mathematical Society offers two kinds of funding for NZ mathematicians: NZMS Student travel grants (financial support etc.) and NZMS Financial Assistance grants (funds for mathematical related activity).

There are quarterly deadlines for applications. The deadline for applications for 2025 are February 15, May 15, August 15, and November 15.

Applications must be made at least 1 month in advance of the travel or event. Please contact the secretary secretary@nzmathsoc.org.nz to get the application forms, and guidelines on how to apply.

Geertrui Van de Voorde (Secretary)

# New books from SAM



Computational Methods in Optimal Control: Theory and Practice • William W. Hager 2025 • xiv + 160 pages • Softcover • 9781611978254 • List \$62.00 • Member \$43.40 • CB100

Uncertainty Quantification: Theory, Implementation, and Applications, Second Edition • Ralph C. Smith 2024 • xxiv + 546 pages • Softcover • 9781611977837 • List \$89.00 • Member \$62.30 • CS30

An Introduction to Stellarators: From Magnetic Fields to Symmetries and Optimization Lise-Marie Imbert-Gérard, Elizabeth J. Paul, and Adelle M. Wright 2024 • xviii + 290 pages • Softcover • 9781611978223 • List \$77.00 • Member \$53.90 • OT202

Implicit-Explicit Methods for Evolutionary Partial Differential Equations Sebastiano Boscarino, Lorenzo Pareschi, and Giovanni Russo 2024 • x + 323 pages • Softcover • 9781611978193 • List \$89.00 • Member \$62.30 • MM24

Design of Delay-Based Controllers for Linear Time-Invariant Systems Adrián Ramírez, Rifat Sipahi, Sabine Mondié, and Rubén Garrido 2024 • xxii + 186 pages • Softcover • 9781611978131 • List \$73.00 • Member \$65.70 • DC42

Mathematics and Finite Element Discretizations of Incompressible Navier–Stokes Flows Christine Bernardi, Vivette Girault, Frédéric Hecht, Pierre-Arnaud Raviart, and Beatrice Rivière 2024 • xviii + 840 pages • Softcover • 9781611978117 • List \$99.00 • Member \$69.30 • CL90

## **Optimal Transport: A Comprehensive Introduction to Modeling, Analysis, Simulation, Applications** Gero Friesecke

2024 • xii + 333 pages • Softcover • 9781611978254 • List \$79.00 • Member \$55.30 • CB100

**Data-Driven Methods for Dynamic Systems** • Jason J. Bramburger 2024 • x + 169 pages • Hardcover • 9781611978155 • List \$64.00 • Member \$44.80 • OT201

Numerical Mathematics • Jeffrey Ovall 2024 • xxiv + 604 pages • Softcover • 9781611978063 • List \$89.00 • Member \$62.30 • OT198

**Time Parallel Time Integration •** Martin J. Gander and Thibaut Lunet 2024 • xii + 260 pages • Softcover • 9781611978018 • List \$79.00 • Member \$55.30 • CB99

