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# NEWSLETTER

OF THE

NEW ZEALAND MATHEMATICAL SOCIETY

## Contents

# PUBLISHER'S NOTICE

This newsletter is the official organ of the New Zealand Mathematical Society Inc. This issue was edited by Fabien Montiel and Melissa Tacy. 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 nzmsnews@maths.otago.ac.nz. LaTeX templates are available upon request from the editors.

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## NZMS Council and officers



## Other positions of responsibility



## Correspondents



### Web Sites

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The newsletter is available at: nzmathsoc.org.nz/?newsletter
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# EDITORIAL

We now find ourselves at the end of a tumultuous year and hope that the members of the NZMS are finding some time to unwind over the summer break.

September brought the news of New Zealand mathematician (and Fields medalist) Vaughan Jones sudden death. Marston Conder, Rod Downey, David Gauld and Gaven Martin have provided us with an obituary touching on his life and mathematics.

The year seems to be ending on a better note, however, with the news that several vaccines have now successfully completed phase 3 trials and are already being distributed to vulnerable people in several countries. What an incredible scientific achievement that is and a testament to humans' ability to solve hard problems fast when sufficient resources are given to scientists.

The NZMS Colloquium was also held online in December with special sessions on COVID-19 modelling and online teaching, which was a good way for our community to reflect on this past year and discuss the lessons learnt. We would like to thank Shaun Hendy for his service as President of the NZMS and welcome David Bryant in this new role.

In our April edition we asked the members of the NZMS to think about what they would like to keep (and what they would like to leave) from the rapid move to online that hit us in 2020. Here, in no particular order, are some of our thoughts.

**Melissa**

- I'd like to keep the option of presenting at a conference online however I think it's important that this option be the speaker's choice. I'd hate to end up in a world where there were two tiers of invitees to conferences (online and in person). Rather I'd like a system where organisers invited participants/speakers but gave them the option to choose to participate online.
- The idea that you stay home if you are sick is one I'd like to see continue. Particularly if we could pair it with working form home. That is, sick days are for the days when you are actually too sick to work (or caring for someone who is) but if you are contagious but can work from home this should be a possibility rather than needing to use a sick day.
- On the teaching side I would like to be able to use pre-recorded videos for some examples/theorem proofs. One thing that has become apparent is that the structure of having in person classes and interacting with lecturers and tutors is vital for student success. However within that structure we probably don't need to reproduce the same example for each new year of classes. It will take a while to get the balance right, but I hope we will be given the chance to do so.

**Fabien**

- Piggy-backing on Melissa's thought regarding online conferences, I think in-person attendance may need to be prioritised to people who need the networking experience the most, e.g. postgrad students and ECRs. Even without a pandemic, international travel will have to be cut down significantly to reduce carbon emissions. Regional hubs could be a compromise. I don't know what the best solution is, but it is probably a good idea to experiment and maybe a solution will emerge via trial and error.
- Assessing students without invigilated exams seems to have been another big issue this year. Based on the online teaching panel discussion on day 2 of the NZMS Colloquium, it seems there is no clear solution to this problem. Maybe new ways of assessing students should be trialled, e.g. report writing, oral presentations, etc. We will be developing a new first-year paper at Otago next year that will be 100% internally assessed. I would be happy to report on its implementation and the student response after we have offered it in 2022.
- Finally, let's take a moment to reflect on how fortunate we are to be NZ at the moment. Most of us have family, friends and colleagues overseas who have been suffering immensely more than we have. Shifting perspective and meditating on this can make some of the problems we complain about less important and even go away.

*Fabien Montiel and Melissa Tacy*

# PRESIDENT'S COLUMN

Kia ora koutou,

It has been a great honour to be President of the New Zealand Maths Society this year, so it is with a lot of sadness that I have had to resign. The COVID modelling work that I have been doing this year with Alex James, Mike Plank, Rachelle Binny and others, has come to dominate my time to the extent that I've not been in a position to carry out much of the Society's business and that is set to continue for the next year. Vivien Kirk and Rua Murray have very kindly picked up the overflow, but it is unfair to ask them to do this for any longer. I am very pleased to be able to hand over to David Bryant from the University of Otago who was elected as President at the December AGM. It is very reassuring to leave the Society in such capable hands. I do have to pass on my very special thanks to Vivien and Rua for going beyond the call of duty this year as well as acknowledging their contributions to Council in very challenging times.

It has been a difficult year for the New Zealand mathematics community. The impacts of COVID-19 have been felt everywhere, but most acutely by early career researchers. Many have experienced disruptions to studies and face an uncertain future, with options for employment overseas narrowing and New Zealand research organisations axing jobs. Quite apart from the challenge of COVID, the mathematics community have also grappled with an aggressive restructuring at Massey that directly affects a number of our members and has the potential to hurt the community more broadly. We have made several submissions to Massey University pointing out that they have failed to take account of research impacts in their decision-making, but have not had a substantive response.

Nonetheless, we should be very proud of the contributions mathematics and mathematicians have made to New Zealand this year. Rachelle Binny, a mathematician at Crown Research Institute Manaaki Whenua, was awarded a Science New Zealand early career research award in December, in part for her contributions to Te Pūnaha Matatini's COVID-19 modelling programme. Melissa Tacy, who won the Kalman Prize for Best Paper this year, has worked hard on Council this year to establish a peer mentoring network for early career mathematicians. Eamonn O'Brien won the 2020 Hector Medal of the Royal SocietyTe Apārangi, which is awarded annually for outstanding work in chemical, physical or mathematical and information sciences by a researcher in New Zealand.

On that note, I hope you all have a restful break after what has been such a difficult year.

*Shaun Hendy*

## Fellowships of the New Zealand Mathematical Society

Fellowship of the NZ Mathematical Society is awarded to members of the NZMS in recognition of their contributions to mathematics and their professional standing in the NZ Mathematics community. There are four new Fellows in 2020:

**Douglas Bridges (University of Canterbury)** Douglas has made substantial and sustained contributions to mathematical research in constructive analysis, topology, logic, set theory and mathematical economics. He has also served the NZ mathematics community through a term as President of the NZMS, service on NZMS and RSNZ committees, and through his research leadership over many years.

**Tammy Lynch (Massey University)** Tammy has made numerous impactful contributions to mathematics teaching and to research in applied mathematics, and has received several awards for distinguished teaching and research. She has also made a sustained contribution to the NZ mathematics community through her service to the NZMS, including 7 years so far on the Council and organisation of the NZMS Colloquium, and through her leadership roles in mathematics at Massey University.

**Jeanette McLeod (University of Canterbury)** Jeanette has made an important contribution to mathematics in NZ through the Maths Craft outreach initiative that she founded, with Phil Wilson, in 2016. Maths Craft has brought mathematics in a fun way to many thousands of NZers through hands-on crafting events. Jeanette has also made substantial contributions through her research in combinatorics and graph theory.

**Phillip Wilson (University of Canterbury)** Phil has made an important contribution to mathematics in NZ through the Maths Craft outreach initiative that he founded, with Jeanette McLeod, in 2016. He has also made strong contributions through his research in fluid dynamics and mathematical biology.

## Aitken Prize

The Aitken Prize is normally awarded to the best student talk at the Maths Colloquium. This year, however, the prize was awarded to the best talk at the New Zealand Mathematics and Statistics Post-Graduate Student Conference. The winner of the Aitken Prize for 2020 was **Pedro Henrique Barboza Rosetto (Otago)** for his talk "Chaos in Plane Fronted Gravitational Waves". The judging panel also awarded two "Highly Commended" certificates this year for the following talks: **Morgan Meertens (Auckland)** for her talk "Folded homoclinic bifurcations", and **Ravindra Bandara (Auckland)** for his talk "Infinitely Many Multipulse Solitons of Different Types in a Waveguide with Quartic Dispersion".

## Early Career Research Award

The Early Career Research Award recognises excellent research carried out by early-career New Zealand-based mathematicians and is based on three published research outputs. The 2020 award goes jointly to two people:

**Geertrui Van de Voorde (University of Canterbury)** For profound contributions to finite geometry, particularly creative and foundational analyses of linear sets and their applications to coding theory.

**Gabriel Verret (University of Auckland)** For contributions to discrete mathematics and group theory, including the introduction of new approaches that have led to many new discoveries and the answers to long-standing questions.

## Research Award

The Research Award recognises excellence in research carried out by mathematicians in New Zealand and is based on research published in the last five years. This year the award goes to:

**Jeroen Schillewaert (University of Auckland)** For his outstanding and diverse contributions to a broad range of topics in combinatorics and finite geometry, combining techniques from extremal and probabilistic combinatorics, linear algebra, and group theory.

## Kalman Prize for Best Paper

The Kalman Prize is awarded for an outstanding and innovative piece of research in the mathematical sciences published by a member or members of the NZMS within the last 5 calendar years. The 2020 Prize goes to:

**Melissa Tacy (University of Auckland)** For the paper "$L^p$ estimates for joint quasimodes of semiclassical pseudo-differential operators", published in 2019 in the Israel Journal of Mathematics.

## Gillian Thornley Award

This award is for an outstanding contribution to the cause or profession of mathematics, and is made for the first time this year. There are two joint winners:

**Liz Ackerley (University of Canterbury)** For her work with mathematically-promising secondary school students. Liz has taught, mentored, inspired, guided, and cared for over a thousand young mathematics students over almost a quarter of a century through the University of Canterbury's Maths 199 course, providing a bridge for these students to university mathematics.

**Rachel Passmore (University of Auckland)** For sustained and impactful contributions to improving access to mathematics and the quality of mathematics teaching at secondary school level in New Zealand. Rachel has been the driving force behind numerous initiatives to provide continuing education opportunities for mathematics school teachers and to improve access to study opportunities involving mathematics and statistics for students from a wide range of backgrounds.

# EDUCATION

As a subject, mathematics has "built up a level of technology and jargon that's impenetrable if you come at it face on" [1]. Years of study may be required for someone to attain basic competence in a research area, i.e., know enough to follow more than the first 5 minutes of a talk. But just because something is hard work doesn't necessarily mean it is recognised or appreciated. For administrators looking to balance budgets, it could be expendable. Musicians and other artists also spend years perfecting their skills, but this will not necessarily stop funding cuts to the arts [2].

What tends to save mathematics is the fact that it is considered to be an essential subject. Students in other degree programmes are required to do maths, which boost our enrolment numbers. When cuts to maths or science are in the works, we roll out the 'essential' argument, warning of dire consequences [3]. (It's not just an argument—it's the truth!)

So, it is better for us if more areas of maths become essential. The transmission of mathematics further into society also has measurable economic benefits [4]. Such transmission happens with the help of scientists, engineers, economists etc. on our periphery. Therefore, bringing mathematics to this wider layer is a worthwhile task. Conferences, informal networks, and interdisciplinary teams can connect mathematicians with other scientists on a personal level, but when it comes to serious learning, there is no substitute for study programmes and materials.

Education ought to be a strength of mathematics departments—teaching students, assessing them, and creating notes is part of their job, and mathematicians' knowledge of their own subject is second to none. Books, courses, electronic resources, etc. of high quality can be used to reach people who may not be mathematicians, but have sufficient appreciation of the subject and some motivation to increase their knowledge. (This could be for personal interest, or as part of their job.)

Putting in the extra effort to make mathematics accessible pays off. I mention a couple of examples.

In 1991, David Cox, John Little and Donal O'Shea wrote the first edition of their bestselling book *Ideals, Varieties and Algorithms*. Its aim was to "introduce undergraduates to some interesting ideas in algebraic geometry and commutative algebra". But they also became accessible to a wide audience of scientists and engineers. The ideas have even been popularised in areas which the authors did not imagine when they were writing the book.[1]

From 1968 to 1973, Herbert Gross produced the video course "Calculus revisited", which included introductory complex analysis and differential equations. Clearly a lot of effort went into making the videos and supplementary notes as accessible as possible. The course materials can be found online at MIT open courseware [5] and the (black and white) videos are on youtube.[2] (Check out the comments on his videos.)

A good level to aim at seems to be the end of second year, or 200-level. Material pitched at this level:

1. Is within reach of an important layer of non-mathematicians on the periphery of the subject.[3]

2. Is well inside the comfort zone of a professional mathematician, but getting too advanced for anyone else to teach.

A particular area of mathematics may be unused only because it is relatively unknown. Accessible notes, exercises and examples can bring it to a wider audience. Over the past couple of decades a lot of material has been put onto the internet; some good stuff and a lot of junk. In addition to writing resources, one can also compile existing online resources into a coherent programme of study. (Similar in spirit to Gerard 't Hooft's website [6], but with less ambitious goals.)

You never know what sort of mathematics could take off next, but there are some interesting stories [7].

In conclusion, education and communication are important for realising the potential of mathematics more widely. Although most high-level mathematics is inaccessible to nonspecialists, there may be interesting parts that can be simplified and transmitted to a wider group of people. I think that this sort of work is just as important for our field as mathematical research. Perhaps down the line such material could formally evolve into actual courses, or micro-credentials for *lifelong learning*. (Is this still a buzzword?) The more mathematics is learnt and used, the more essential it becomes. In our current political and economic climate, this is important!

[1] This was mentioned at David Cox's retirement conference in 2019.

[2] Thanks to Garry Nathan for showing me this two months ago. Professor Gross sadly passed away in May 2020.

[3] In the terminology of Educational Psychology, it is in their *zone of proximal development*.

## References


[1] Gaven Martin, quoted in *Star of the West* by Donna Chisholm. *North & South*, June 2010. https://www.math.auckland.ac.nz/mathwiki/images/c/cf/Gaven_Martin_North_and_South_June_2010.pdf

[2] *Standing Room Only*, Radio NZ, 21 June 2020. https://www.rnz.co.nz/national/programmes/standing-room-only/audio/2018751576/funding-cuts-for-the-arts-as-local-councils-feel-the-squeeze

[3] *Open Letter Regarding Massey University's Cuts to Science from the Presidents of New Zealand's Scientific Societies*. http://bit.ly/MasseyCuts

[4] *Measuring the Economic Benefits of Mathematical Science Research in the UK*. Deloitte Report, June 2013. https://www.lms.ac.uk/news-entry/06122012-1417/deloitte-report-measuring-economic-benefits-mathematical-science-research

[5] Herbert Gross MIT courses. https://ocw.mit.edu/search/ocwsearch.htm?q=HerbertGross

[6] *How to become a GOOD Theoretical Physicist*. https://webspace.science.uu.nl/~gadda001/goodtheorist/index.html

[7] *The unplanned impact of mathematics*. Peter Rowlett, *Nature* **475**, 166–169, 2011. https://www.nature.com/articles/475166a

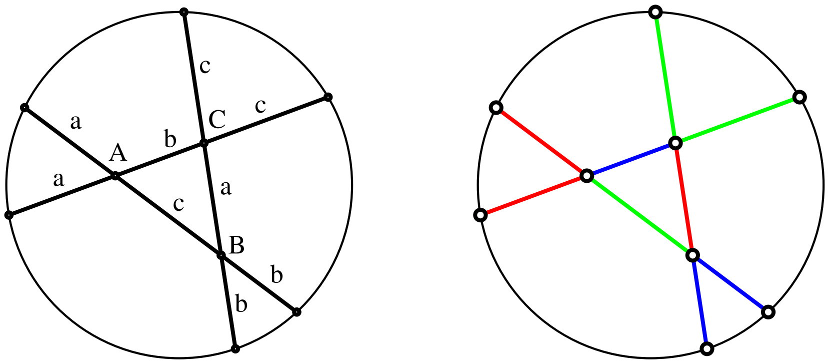

*Sione Ma'u*

# MATHEMATICAL MINIATURE

## MM52: Lorem Mathem

The pseudo Latin text Lorem Ipsum is widely used as a space-filler in graphic designs. If we wanted a space-filler that looked like mathematics, just as Lorem Lipsum looks like Latin, where would we find it? The countless mathematical articles, which are sometimes read by nobody except the author, and a peer reviewer, might provide a rich source of what I am dubbing "Lorem Mathem". My worst fear is that these miniatures, which I have penned on and off for 24 years, might be little more than this. I would really love it if one or two of my loyal readers, if there are any, would write to me with a friendly word.

In MM51, which I dedicated to the memory of John Conway, was intended to be a wordless theorem and proof. Maybe someone was able to work out what it meant but, if so, they never told me. I will now give a hint to what the strange pictures meant. On the left is a diagram built round a triangle $ABC$ and on the right is an identical diagram with colours indicating intervals of the same lengths.




The sides of the triangle are extended for the lengths marked in the diagram. The six points constructed in this way are concentric and lie on "Conway's circle". The other diagrams in MM51 are intended to suggest a possible proof.

My worst Lorem Mathem fears were put to rest last week. A medical physicist in USA, working on radiation therapy, wrote to see if I could give him a hint on how to prove a conjectured result on the basis of a mathematical miniature from more than 20 years ago.

Today's puzzle refers to Legendre symbols. For a prime $p$,

$$\left(\frac{n}{p}\right) := \begin{cases} 0 & n|p, \\ 1 & n \not| p \text{ and } n \text{ is quadratic residue of } p, \\ -1 & n \not| p \text{ and } n \text{ is quadratic non residue of } p. \end{cases}$$

Define a $p \times p$ matrix $T$ with $(i, j)$ element equal to

$$T_{ij} = \left(\frac{i-j}{p}\right).$$

Prove that $T^{\mathsf{T}}T$ has diagonal elements equal to $p-1$ and off-diagonals equal to $-1$.

For example, if $p = 5$,

$$T = \begin{bmatrix} 0 & 1 & -1 & -1 & 1 \\ 1 & 0 & 1 & -1 & -1 \\ -1 & 1 & 0 & 1 & -1 \\ -1 & -1 & 1 & 0 & 1 \\ 1 & -1 & -1 & 1 & 0 \end{bmatrix}, \qquad T^{\mathsf{T}}T = \begin{bmatrix} 4 & -1 & -1 & -1 & -1 \\ -1 & 4 & -1 & -1 & -1 \\ -1 & -1 & 4 & -1 & -1 \\ -1 & -1 & -1 & 4 & -1 \\ -1 & -1 & -1 & -1 & 4 \end{bmatrix}.$$

*J.C. Butcher*
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# MATHEMATICAL MISEPONYMY

## Stirling's Formula

I am referring, of course, to the formula $n! \simeq \sqrt{2\pi n}\left(\frac{n}{e}\right)^n$. (How many readers have met the notation used when I first met $n!$, viz $\lfloor\underline{n}$ ?)

There seem to have been two early players in the discovery of this formula: James Stirling and Abraham De Moivre. In the late 1680s De Moivre went into religious exile from his native France and stayed in London for the rest of his life. The younger Stirling spent about a decade in London from the middle of the 1720s. Each published a book in 1730, De Moivre [2] and Stirling [6], and each was aware of the other's work. Each was interested in calculating $n!$ for a range of values of $n$. Indeed, [6, Proposition 28, Example 2] gives an explicit calculation of the logarithim of 1000! to ten decimal places while a supplement attached to [2] includes a table of 14 figure logarithms of $n!$ for $n = 10, 20, \ldots, 900$.

There seem to be opposing views regarding who should get priority credit. Though [5] is primarily concerned with the normal curve, so ubiquitous in Statistics, the author does devote some discussion to Stirling's formula and gives De Moivre primary credit, ending his paper with

> In the same way we ought at least to speak of the De Moivre-Stirling Theorem, if we retain in part Stirling's name as contributor of the $\sqrt{2\pi}$.

On the other hand in [4] the author devotes a section each to relevant work of De Moivre and Stirling followed by a section entitled *The asymptotic developments of De Moivre and Stirling*. In the section on De Moivre, he notes, [4, p 227],

> the approximate evaluation of factorials for large values of the argument, does not appear to have been considered before the work of Abraham de Moivre about 1721.

Then the following statement appears near the end of that section ([4, p 236]):

> . . . it is frequently stated that Stirling's contribution was limited to the evaluation of the constant in De Moivre's series.

In [5] the author refers to what he calls a rare supplement, [3], to De Moivre's 1730 book: indeed, Pearson in a footnote lists 12 copies of [2] in the UK, only one of which contains [3]. Noting that De Moivre makes use of his formula $m! = \text{const.} \times \sqrt{m}e^{-m}m^m$ and that he determines the constant to be 2.5074, Pearson goes on to quote De Moivre as saying that his friend Stirling "after me brought himself to the subject by a very different process, showed that the value" of the constant was $\sqrt{2\pi}$, about 2.5066. Pearson then goes on to say:

> I consider that the fact that Stirling showed that De Moivre's arithmetical constant was $\sqrt{2\pi}$ does not entitle him to claim the theorem, and that it is erroneous to term it Stirling's Theorem.

So Dutka and Pearson give contradictory views on who should get credit but maybe it is worth noting that Dutka cites neither [3] nor [5]. Dutka further helps in [4, Section 5] by assigning dates to various details. In 1721, by analysing the binomial expansion of $(1+1)^n$, De Moivre came up with the approximation $\binom{n}{n/2}\frac{1}{2^n} \simeq \frac{2A}{\sqrt{n-1}}(1-\frac{1}{n})^n$, where $2A$ is a constant, but it was not published until 1730. Dutka states that the question of approximation came to Stirling's attention in 1725 and in 1729 Stirling included in a letter to De Moivre a formula for $\binom{2n}{n}\frac{1}{2^{2n}}$.

Two other publications seem to help us solve the riddle. Archibald[4] in [1] summarises Pearson's argument and also quotes from De Moivre, $B$ being the constant whose approximate value De Moivre gave as 2.5074:

> I desisted from proceeding further, till my worthy and learned friend Mr. James Stirling, who had applied himself after me to that inquiry, found that the quantity $B$ did denote the square-root of the circumference of a circle whose radius is unity.

[4] According to Wikipedia, Raymond Clare Archibald was a fourth cousin twice removed of Simon Newcomb who suffered from miseponymy in the naming of Benford's Law, as discussed in *Mathematical Miseponymy*, NZMS Newsletter 132.

Helpfully Archibald also included in the second half of [1] a facsimile copy of [3]; the quote above is a translation of the original Latin appearing at [3, p 2].

The second of these publications is [7] which, in addition to translating Stirling's book into English, includes over 100 pages of notes by Tweedle. One can find Stirling's calculation of the logarithm of 1000! at [7, p 151]. Then in Tweedle's notes at [7, p 271] and [7, p 272] respectively we find $m! \simeq \sqrt{2\pi}\left(\frac{m+\frac{1}{2}}{e}\right)^{m+1/2}$ and $m! \simeq \sqrt{2\pi m}\left(\frac{m}{e}\right)^m$ as Stirling's and De Moivre's versions of the formula.

# References


[1] Raymond C. Archibald, *A Rare Pamphlet of Moivre and Some of His Discoveries*, Isis 8(4)(1926), 671–83. Accessed November 6, 2020 at http://www.jstor.org/stable/223870.[5]

[2] Abraham de Moivre, *Miscellanea Analytica de Seriebus et Quadraturis*, London, 1730.

[3] Abraham de Moivre, *Approximatio ad Summan Terminorum Binomii* $(a+b)^n$ *in Seriem expansi*, 1733 pamphlet attached to some copies of [2].

[4] Jacques Dutka, *The Early History of the Factorial Function*, Archive for History of Exact Sciences, 43(3)(1991), 225–249.

[5] Karl Pearson, *Historical Note on the Origin of the Normal Curve of Errors*, Biometrika, 16(3/4)(1924), 402–404.

[6] James Stirling, *Methodus Differentialis: sive Tractatus de Summatione et Interpolatione Serierum Infinitarum*, London, 1730.

[7] Ian Tweedle, *James Stirling's* Methodus Differentialis*: An Annotated Translation of Stirling's Text*, Sources and Studies in the History of Mathematics and Physical Sciences, Springer-Verlag, London, 2003.


*David Gauld*

[5] Isis lists R. C. Archibald as the sole author but JSTOR lists Pearson and De Moivre as co-authors in that order before Archibald.

# PROFILE

## Cami Sawyer


A talented mathematician, an inspiring educator and an award winning teacher! Cami's modesty would prevent her from saying such things about herself, but all those who know her are struck by her enthusiasm, work ethic, kindness and intelligence.

Cami first came to New Zealand in the late 1980's as a Rotary Scholar and took the opportunity to return permanently in the early 2000's with her husband Greg and two young children, Matthew and Addi. With a PhD in Algebraic Topology from the University of North Texas and a PG Diploma in Teaching from Texas State University, Cami's talents were already in demand. She began her working life in Palmerston North as a Secondary School Mathematics teacher and was soon snapped up by Massey University's School of Fundamental Science as a Senior Tutor. For the last 6 years Cami has worked tirelessly delivering high quality distance learning to school leavers, international students, second-chance students and those juggling families and full-time work around their study. The challenges of managing such a diverse student cohort in a distance learning environment are immense, but Cami sought innovative solutions to manage and conquer these challenges. In 2019, Cami was recognised for her work with a national Sustained Excellence in Tertiary Teaching award.

In terms of research, Cami has moved away from her PhD subject in pure mathematics to focus on educational research in the teaching of mathematics. She is an advocate for the use of technology in education and is constantly trying to incorporate the latest research in this area, always sharing her knowledge and ideas with others. Her classroom environment creates a safe space for students, many of whom suffer from maths anxiety, and she works hard to build trust between her and her students. Creating these relationships with students in a distance learning environment requires the development of multiple versions of resources to cope with different learning styles and skill levels. Cami's experiences with distance learning and proficiency with educational technology has been particularly valuable in 2020, with educators from around the country benefitting from her expertise.

Cami's knowledge and experience of secondary school teaching, combined with her work with school leavers has led her to examine the transition between learning mathematics at school and at university. Cami discovered a considerable disconnect between the various stake-holders and became motivated to instigate and promote dialogue in order to improve the transition for students. Her role as Chair of the NZMS Education Group is just part of her strategy to facilitate this dialogue; the energy she brought to this role has been amazing, fuelling much discussion amongst academics from Universities across NZ, secondary school teachers, the Ministry of Education and the NZQA.

An important aspect of Cami's teaching is relationality; making genuine and meaningful connections with students and their culture. The Pūhoro STEM academy was set up by Massey University to support young Māori students from Year 11, on their journey through to the completion of tertiary studies. Cami recognised the value of this programme, but realised that mathematics support was lacking for the programme. Cami filled this void and has been an active member of the Pūhoro STEM academy since 2015. Experience with this programme fuelled her desire to learn more about Te Reo, Mātauranga Māori and mathematics in order to develop a deeper understanding of the needs of Māori students and their relationship with the subject of Mathematics. In January 2020, Cami brought together a number of Māori educators to explore Mātauranga Māori and Mathematics. After the January hui, Cami was able to reconsider Mātauranga Māori as a process which could be incorporated into mathematics teaching by the inclusion of group work and the development of knowledge through collaboration and group work.

In addition to her work with the Pūhoro STEM academy Cami is active in a number of other outreach activities, she runs workshops for scholarship students, organises maths competitions for Year 12 students, facilitates maths activities for Year 10 Massey Open Days, and presents at several professional development events hosted by the NZ Association of Mathematics Teachers. Cami's energy for mathematics and her students appears boundless. She is driven by the goal of improving perceptions of mathematics, attracting diverse student cohorts to the subject, enabling all students to reach their full potential. Cami shares her knowledge and expertise, bringing people together impacting other institutions, government agencies, schools and colleagues. Her work has impact across New Zealand and students will be benefitting from this work now and long into the future.

*Julia Novak and Rachel Passmore*

# LOCAL NEWS

## UNIVERSITY OF AUCKLAND

### DEPARTMENT OF MATHEMATICS

We were shocked by the news of Vaughan Jones' sudden death. Vaughan had been a Distinguished Professor in the department for many years. There will be a memorial event on December 7th to celebrate his remarkable life.

It has been another stressful and demanding semester with teaching and assessing. Auckland experienced a lockdown in the middle of the semester, with about 5 weeks of teaching online, and there was a further disruption during the examinations period in November, resulting in the last week or so of examinations being online.

About 8 staff (including some on new contracts) and a number of PhD students are out of New Zealand and are anxious to be able to enter the country.

To add to the stress, the University of Auckland embarked on a "voluntary leaving scheme" with the aim of reducing total salary commitments to help bridge the shortfall in international student fee income.

If that wasn't enough, a major construction/destruction project is underway a few metres from the Mathematics Department. A number of staff have lost all natural light in their offices due to hoardings. We have been investing in noise-canceling headphones for staff. In about 3 years time we will have an enormous recreation centre and swimming pool.

So now for some good news:

**Hector Medal**

Eamonn O'Brien was awarded the Hector Medal of the Royal Society of New Zealand Te Apārangi. The Hector Medal is awarded annually for outstanding work in chemical, physical or mathematical and information sciences by a researcher in New Zealand.

Eamonn's citation reads: Eamonn has made world-leading contributions to the mathematical theory of groups, both through theoretical breakthroughs and his powerful algorithms. These algorithms are now incorporated into the computer algebra systems GAP and MAGMA that allow mathematicians world wide to access these cutting-edge computational research tools. He has solved difficult and significant long-standing research problems, including a 40-year-old challenge posed by Alan Turing and the 50-year old Ore Conjecture. As a research leader, he brings people together from different areas to work on new problems and has helped foster the University of Auckland as a strong research centre for algebra.

**New arrivals**

Lukas Zobernig, Melissa Lee, Jason Legrow and Matthew Conder have started research fellow positions in the department (two of them remotely).

Sudeep Stephen will be employed as a temporary lecturer for the first half of 2021.

Tomasz Popiel will be a temporary lecturer for one year in 2021.

**Major grants**

We are happy that the COREs Te Pūnaha Matatini (TPM) and the Dodd Walls Centre (DWC) were refunded. TPM features a number of our mathematical friends from around NZ (and upstairs in building 303), including current NZMS President Shaun Hendy. The recent successes of TPM, especially in COVID modelling, have been a much-needed boost to the profile of Mathematics in NZ. From our department, Claire Postlethwaite is an Associate Investigator at TPM. Bernd Krauskopf and Hinke Osinga are Principal Investigators for the DWC, and Marie Graff and Claire Postlethwaite are AIs. DWC is presently supporting in the department postdocs Andrus Giraldo and Stefan Ruschel, and PhD students Ravindra Bandara and Rodrigues Bitha (both jointly with Neil Broderick in Physics, who is the Deputy Director of the CORE).

Congratulations to Jianbei An, Marston Conder, Marie Graff, Vivien Kirk, Eamonn O'Brien, and James Sneyd on their Marsden success. The project "Modelling calcium dynamics in living animals: multiple time and space scales in theory and practice" has Vivien and James as PIs, and Marie as an AI. The project "Group structure, actions, representations and algorithms" has Jianbei, Marston and Eamonn as PIs.

**Other news and events**

The conference "A Mathematical Medley" on various aspects of mathematics and its applications took place at the University of Auckland on Thursday 19 and Friday 20 November. This event was rescheduled from September because of Covid 19 restrictions. The event was partly in honour of Marston Conder's 65th birthday. The speakers were: Alice Devillers (UWA), Pedram Hekmati (Auckland), Gaven Martin (Massey), Dillon Mayhew (Victoria), Claire Postlethwaite (Auckland), Mike Steel (Canterbury), Gabriel Verret (Auckland), Caroline Yoon (Auckland).

The Science Faculty Graduation Ceremony took place on Tuesday 6th October at the Spark (formerly Vector) Arena.

The PhD thesis "Skew Morphisms and Skew Product Groups of Finite Groups" by Martin Bachratý has been placed on the Dean of Graduate Studies List (Dean's List) in recognition of excellence achieved. Martin was supervised by Gabriel Verret and Marston Conder.

John Butcher was a speaker at the International Conference on Advances on Differential Equations and Numerical Analysis (ADENA2020).

Steven Galbraith was the Jennifer Seberry Invited Lecturer at the 25th Australasian Conference on Information Security and Privacy (ACISP). He also chaired a panel at the Elliptic Curve Cryptography 2020 conference, and was a contestant on a comedy version of the game show Jeopardy! at the CRYPTO 2020 conference "rump session".

The Kalman Trust continues to fund activities (coordinated by Rachel Passmore) to promote high quality teaching of Mathematics. The Trust awards the Kalman Teacher Excellence Prize (awarded this year to Michael Walden of Mt Albert Grammar School) and the Kalman Teacher Fellows (who spend a few days in the Mathematics Department work on a professional development project).

*Steven Galbraith*

## UNIVERSITY OF WAIKATO

### DEPARTMENT OF MATHEMATICS AND STATISTICS

#### Promotions

Sean Oughton was promoted to professor earlier this year. His inaugural lecture was given in early December and entitled *Turbulence, in particular solar wind turbulence, in outer space*. It was followed by a Department dinner celebration to congratulate Sean. An official ceremony to confer the title of Emeritus Professor on Ernie Kalnins was held in late September. We celebrated in the department with drinks and nibbles.

#### Jacob Heerikhuisen Marsden grant

Jacob joined with staff from the School of Psychology to form an interdisciplinary group for a Marsden grant application, which was successful. The project title: *Development of the human visual system in utero: an experimental and computational modelling approach.* His particular contribution will be to the mathematical modelling components.

#### Hamish Gilmore completes the PhD

Hamish completed his PhD in late September supervised by Daniel Delbourgo. The title was *$\mathscr{L}$-invariants and congruences for Galois representations of dimension 3, 4, and 8.* The thesis included a report on a computational study of invariants attached to symmetric squares of modular forms, and established congruences between $p$-adic $L$-functions. It earned high praise from the examiners.

A dinner was held to celebrate Hamish's success.

Hamish Gilmore (second from the left) dinner 29 September 2020

#### The engineers ascend

Under the leadership of Prof Mike Walmsley (Engineering), a long term research project was proposed and consequently well funded by MBIE. Its goal is to build a computational platform, Ahuora, to enable large energy users to process industrial heat efficiently, targeting net-zero greenhouse gas emissions. They intend to construct a flexible software model of industrial processes so companies can test different potential innovation plans.

Staff from the School of Computing and Mathematical Sciences will be involved, especially in the software engineering and optimization components. A large number of new staff are being appointed, and one of the most visible effects for the department is a significant loss of space, including offices, student rooms, and lab space on the third floor of block G.

#### Redundancies

Like other NZ universities, Waikato has its budgetry woes. Staff over 60 have been visited and encouraged to take early retirement with an offer of a financial inducement. A significant loss of high quality people is expected. Unlike Massey, there has been little revising of academic programs.

#### Teaching plans for 2021

It is expected that teaching will revert to something more normal in 2021, with much more face-to-face teaching, but a continuation of an on-line option for those who cannot make it to the campus. Examinations, unlike the system used in 2020, will be in class - a sigh of relief is audible!

**Number theory workshop**

A continuation of the successful series of number theory workshops was held at the University in late October. There were 5 presented lectures with face-to-face sessions and a zoom facility for both attendees and presenters, especially those from overseas. The technology worked perfectly. Visitors from Canterbury and Auckland, including staff and students, made for a very worthwhile experience. The day concluded with a dinner.

**Restructuring**

There has been significant restructuring in the School of Computing and Mathematical Sciences. The large Department of Computer Science has been split up into Departments of Computer Science; Design; and Software Engineering. It also looks like the Department of Mathematics and Statistics will become the Department of Mathematics. Daniel Delbourgo is the Head of Department while Tim Stokes is the Deputy Head. Because of their research interests, some of the statisticians have joined other departments.

*Kevin Broughan*

## MASSEY UNIVERSITY

### INSTITUTE OF FUNDAMENTAL SCIENCES

A substantial contingent of us thoroughly enjoyed travelling down to Wellington for the annual Wellington-Manawatū Applied Mathematics (WMAM) day in November. It was wonderful to have had the now rare opportunity to attend an in-person mathematics conference – a highlight after what has been a tumultuous year. Many thanks to this year's organising committee at Victoria for organising this meeting.

In November we were also visited by Amanda Hampton who is a graduate student at the University of Colorado at Boulder (but who has been in New Zealand for most of the year). Amanda is working on problems concerning volume-preserving maps and gave a talk at WMAM.

Finally, Robert McLachlan's recently graduated PhD student Christian Offen has started a post-doctoral fellow position at the University of Paderborn.

*Richard Brown*

### SCHOOL OF NATURAL AND COMPUTATIONAL SCIENCES

Mick Roberts has been awarded a Marsden Grant as PI for the project "The dynamics of interacting infections" and Alexander (Sasha) Melnikov is an AI on the grant "New Initiatives in the Theory of Computation". Sasha has also been promoted to Associate Professor.

A second discussion document regarding the future of the College of Sciences was released in October. Two options were presented. For undergraduate mathematics they are (Option 1) discontinue mathematics at both Albany and Manawatū while maintaining a distance offering, and (Option 2) maintain and develop a single blended delivery across campuses and by distance. Under either option the MSc in mathematics would be discontinued. Under either option approximately 100 academic staff within the College would be made redundant.

*Carlo Laing*

## VICTORIA UNIVERSITY OF WELLINGTON

### SCHOOL OF MATHEMATICS AND STATISTICS

PhD student Alex Simpson has won the Post Graduate Student Association's Research Excellence Award for the Faculty of Science. Alex is working on "Black Hole Variants in General Relativity" with Matt Visser.

Noam Greenberg and Rod Downey have published their book "A Hierarchy of Turing Degrees" with Princeton University Press in the "Annals of Mathematics Studies" series. Rod gave a public lecture in Napier, for the Hawke's Bay branch of the Royal Society of New Zealand, about "Mathematics and Scottish Country Dancing".

Martino Lupini has been awarded a Rutherford Discovery Fellowship. His research is titled "Computing the shape of chaos" and will focus on developing a generalisation of alegbraic topology to include fractals, and to find a set of tools for categorising and comparing such objects in real applications.

The School is grateful for our Marsden successes. They are: "Computability, Reverse Mathematics, and Effective Descriptive Set Theory" for Noam Greenberg and Dan Turetsky, "New Initiatives in the Theory of Computation" for Rod Downey, and a fast-start "Matroids representable over GF(4) and other fields" for Nick Brettell.

Estate Khmaladze is an organiser and board member of the new Asia-Pacific Seminar in Probability and Statistics (APSPS). The seminar was organised as a counter-measure to the pandemic and as the platform for good scientific exchange. The APSPS is run by the Board, with senior representatives from India, Singapore, Japan, Australia and NZ, and they hope that it will include representatives from Hong-Kong and continental China in the near future.

The first seminar was held on zoom on November 18. The current programme is complete for the period up to June 2021, but the Board is open to further interesting suggestions.

The 2020 Wellington-Manawatu Applied Mathematics conference was held at the Kelburn campus of Victoria University of Wellington in November, organised by Dimitrios Mitsotakis and Mark McGuiness. This annual conference is hosted in turn by Massey University in Palmerston North and Victoria University. Please see the separate report (with some nice photos).

Peter Donelan is taking up a 12-month 0.4 FTE position as Acting Director of the Centre for Science in Society from 1 November.

*Astrid an Huef*

## UNIVERSITY OF CANTERBURY

### SCHOOL OF MATHEMATICS AND STATISTICS

The COVID-19 pandemic continues to disrupt life at the university. Although under level 1 we were able to have face-to-face classes and on-campus exams, all lectures have been recorded in semester 2 and there is a push to progress online learning options, which takes considerable staff time. With the ongoing travel restrictions all Erskine fellowships have been cancelled for semester 1 of 2021.

In August *Mike Plank* and *Alex James* each received a letter from the Prime Minister, thanking them for their service to Aotearoa and contribution to NZ's world-leading COVID-19 response. They continue collaborating with academics around New Zealand and have developed a media presence sharing their expert COVID-19 modelling. In October Mike was even quoted in the New York Times outlining NZ's response to the COVID19 pandemic.

Congratulations to *Rachael Tappenden* and Tim Candy on the birth of their first child, Liam James Candy, born in September. At the end of the month Rachael won the student unions "Student create your own award" for "Most Unexpected Enthusiasm for Penguins". The jury noted "Rachael's ardent advocacy for the flight of the endangered NZ birds should be an example to us all. Admittedly, MATH203 (a second year course in linear algebra) was not where we were expecting to encounter such passion, but lectures are more fun with a tangent or two!" Fantastic recognition for injecting the creative into class.

Congratulations to *Rosie Cameron* who has been appointed in November as a Scholar in the Distributed Leadership in Teaching Programme, a new initiative coming from the Deputy Vice Chancelor-Academic's office. Rosie will be one of five throughout the university on this programme for developing their teaching practices and integrating disciplinary responsive pedagogies within peer-led professional learning teams. Her project is to redesign and reimagine MATH101 to meet the diverse learning needs of incoming university students. MATH101 Methods of Mathematics is an introduction to calculus, trigonometry and algebra. It is intended for students who need some knowledge of mathematics to support other studies, and for students who wish to prepare for 100-level mathematics courses that require a higher level of previous learning.

Congratulations to *Blair Robertson, Jennifer Brown, Mike Plank* and *Varvara Vetrova* for their roles in the Biosecurity Innovations Cluster one of the three successful Transdisciplinary Research Clusters funded by the Deputy Vice Chancelor-Research's office.

*Günter Steinke*

## UNIVERSITY OF OTAGO

### DEPARTMENT OF MATHEMATICS AND STATISTICS

We are relieved that a rather unusual and certainly stressful year is about to come to an end. In particular, the teaching and exam marking is finished. We observed that students at 200 and 300-level were doing reasonably well in semester two, despite the second Covid outbreak. Similarly, the group of good and very good students at 100-level was also doing well under the circumstances, with a comparable number of A and B grades as in previous years. Unfortunately, the weaker students in our 100-level mathematics service courses were much more seriously interrupted in their learning, resulting in larger failure rates. Moreover, the attendance in lectures was much below average. Partly this can be explained with availability of online lecture recordings, but the analysis shows that many students have never accessed those. Let's hope that the impacts of Covid will not be that strong next year. Finally, many colleagues were not too disappointed to hear that our VC will shortly leave and take on a VC position in Australia, which, coincidentally, happens to be rather well-paid.

Warmest congratulations to *Tim Candy* and his wife *Rachael Tappenden* (UC) on the birth of their son Liam James in late September. We wish you all the best for the exciting new period in your life, Rachael and Tim. All the best to you as well, Liam, son of two mathematicians. . .

The department has celebrated several Marsden successes. *Martin Hazelton* is a PI in the project "Inference for statistical linear inverse problems: theory and practice", for which he received a grant together with colleagues from Auckland and Melbourne. Fabien Mon-

Liam James Candy

tiel is an AI in a grant with Otago colleagues from Marine Science and Zoology, as well as collaborators from ANU. Their project is entitled "How vulnerable are Antarctica's coasts to colonisation?" *Dominic Searles* received a Fast-Start grant for his project "Combinatorial aspects of polynomials". Well done!

Congratulations to the Mathematics and Physics "Green Problem Solvers" team for receiving a 2020 Green Your Scene award from the University. The team, which includes the Department's *Megan Drysdale*, *Tim Jowett*, *Leanne Kirk*, and *Sarah Wakes*, helps to make the University a more sustainable and healthier place. Projects include a worm farm that converts organic waste into fresh, useful compost, saving electric energy, a vegetable garden, plastic recycling, a well-being challenge, namely a stair-climbing competition, and organisation of voluntary work at the Orokonui ecosanctuary.

*Jörg Hennig*

# PhD SUCCESS

## Marnus Stoltz (University of Otago)

**Title**: Predicting the past: Mathematical models and numerical methods in molecular phylogenetics

**Supervisor**: David Bryant

**Abstract**: Molecular phylogenetics is the study of phylogenies and processes of evolution by the analyses of DNA or amino acid sequence data. In this thesis we describe a computationally efficient Bayesian methodology for inferring species trees and demographics from unlinked binary markers. The new diffusion approach coupled with state-of-the-art numerical algorithms allow for analyses of datasets containing hundreds or even thousands of individuals. We demonstrate the scale of analyses possible using a SNP data sampled from 399 fresh water turtles in 41 populations. The method, which we call Snapper, is the successor of the coalescent based method Snapp. A reanalysis of soybean SNP data demonstrates that the two methods are hard to distinguish in practice. We also describe a Bayesian methodology for inferring niches of present and ancestral species of plants from environmental measurements and estimated phylogenies. Fitting the phylogenetic niche model to three conifer species endemic to New Zealand confirms that viable ancestral niches can be inferred. Lastly, in anticipation of even larger genomic datasets we look into graphical processing units as computational tools for efficient model fitting. We introduce a new graphical processing unit based algorithm designed to fit long chain Hidden Markov models, applying this approach to an Hidden Markov model for nonvolcanic tremor events. Our implementation resulted in a 1000-fold increase in speed over the standard single processing algorithm, allowing for a full Bayesian inference of model parameters.

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## Lukas Zobernig (University of Auckland)

**Title**: Mathematical Aspects of Program Obfuscation

**Supervisors**: Steven Galbraith and Giovanni Russello

**Abstract**: Program obfuscation is an active and heavily researched topic in theoretical and applied cryptography. General purpose program obfuscators would revolutionise the field and make designing new cryptosystems redundant. But as we shall see, there are various pitfalls surrounding general purpose program obfuscation. In this work we instead take a step back and consider special purpose program obfuscation for selected problems.

We briefly explore the state of applied program obfuscation and see whether we can bring more theoretical techniques into the field; for this we study the example of evasive predicates.

We construct an obfuscator for fuzzy Hamming distance matching which finds application in biometric authentication, fuzzy extractors, and secure sketches. The security of this obfuscator is based on a new computational assumption rooted in number theory, which we dubbed the modular subset product problem (MSP). We explain our approach to cryptanalysing this problem and give results and conjectures about its (post-quantum) hardness in various parameter ranges.

The Hamming distance obfuscator leads us to another application for special purpose obfuscation: Conjunctions or pattern matching with wildcards. Our conjunction obfuscator is conveniently based on the MSP hardness.

Finally, we give an obfuscator for a special class of deterministic finite automata (DFA). We consider what we call evasive DFAs which cannot be learned from oracle access. The obfuscator is based on techniques related to branching program obfuscation. It solves the problem of obfuscated substring matching where substrings can even be given by regular expressions.

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## Martin Bachraty (University of Auckland)

**Title**: Skew Morphisms and Skew Product Groups of Finite Groups

**Supervisors**: Gabriel Verret and Marston Conder

**Abstract**: A skew morphism of a finite group $B$ is a permutation $\varphi$ of $B$ preserving the identity element of $B$ and having the property that for every $a \in B$ there exists a positive integer $i_a$ satisfying $\varphi(ab) = \varphi(a)\varphi^{i_a}(b)$ for all $b \in B$. Skew morphisms were introduced in 2002 by Jajcay and Širáň in the context of regular Cayley maps. There

is a close relationship between skew morphisms and finite groups with a factorisation $G = BC$, where $C$ is cyclic and core-free in $G$, and $B \cap C = \{1\}$.

In this thesis we use this relationship to prove many new theorems about skew morphisms of finite groups. As an application we classify and enumerate skew morphisms for all finite non-abelian simple groups. We also find and enumerate all skew morphisms for many other groups for which no such enumeration was available to date.

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**Ankit Patel** (Victoria University of Wellington)

**Title**: Rating Ratings: A Quantitative Framework for Constructing Human-Based Rating Systems

**Supervisors**: Ivy Liu and Paul Bracewell

**Abstract**: This doctoral thesis examines the multivariate nature of human behaviour, expressed as performance on context specific tasks, to develop a novel framework for constructing human-based rating systems, also referred to as scoring models. The intent of this framework is to produce reliable, robust, intuitive and transparent ratings, regarded as meaningful, for behaviour prevalent in credit risk, sport player and team evaluation and computer developer assessment domains. In this thesis, Bracewell's (2003) definition of a rating as an elegant form of dimension reduction is extended to a humanistic sense. Specifically, ratings are an elegant and excessive form of dimension reduction whereby a single numerical value provides an objective interpretation of human behaviour or performance.

The data, provided by numerous vendors, is a summary of actions and performances completed by an individual during the evaluation period. A literature review of rating systems to measure human behaviour and performance across the three domains, revealed a set of common methodologies, which were applied to produce a set of rating systems that were used as pilot studies to garner a set of learnings and limitations surrounding the current literature.

By reviewing rating methodologies and developing rating systems a set of limitations and communalities surrounding the current literature were identified and used to develop a novel framework for constructing human based rating systems. The proposed framework adopts a multi-objective ensembling strategy with a layered approach analogous to the neural network framework and implements five key communalities present within many rating methodologies. These communalities are the application of 1) dimension reduction and feature selection techniques, 2) feature engineering tasks, 3) a multi-objective framework, 4) time-based variables and 5) an ensembling procedure to produce an overall rating.

An ensemble approach is adopted because it assumed that human behaviour is a function of the significant human traits affecting behaviour. Therefore, human behaviour is defined as *human behaviour=(trait1,..., traitn)*. Moreover, the framework is a form of model stacking where information from multiple models is combined to generate a more informative model. Rating systems built using this approach are referred to as human-based rating systems which provide a meaningful quantitative interpretation of behaviour or system performance during the evaluation period. These ratings measure how well the quality of human behaviour or performance during a specific time-interval, known as the evaluation period.

The framework introduces a generic methodology for constructing human-based rating systems within the credit risk, sporting and computer developer domains, which produces meaningful ratings. Meaningful ratings must 1) yield good performance when data is drawn from a wide range of probability distributions that are largely unaffected by outliers, small departures from model assumptions and small sample sizes (robust), 2) be accurate and produce highly informative predictions which are well-calibrated and sharp (reliable), 3) be interpretable and easy to communicate and (transparent), and 4) relate to real-world observable outcomes (intuitive).

The framework is developed to construct human-based rating systems across three domains: 1) credit risk environment to evaluate an applicants' credit-worthiness, 2) sports industry to evaluate team and player performances, and 3) developer environment to evaluate coding ability. The approach was tested and validated by constructing rating systems across the three problem domains. The results of these systems were found to be meaningful, in that, they produced reliable, robust, transparent and intuitive ratings. This ratings framework is not restricted to credit risk, sport player and team evaluation or developer assessment data and is applicable in any field where a summary of multivariate data is necessary to understand human behaviour.

Common model evaluation metrics were found to be limited and lacked applicability when evaluating the effectiveness of human-based ratings, therefore a novel evaluation metric was developed. The constructed metric

applies a spherical scoring rule methodology with an embedded analytical hierarchy process to assess the effectiveness of ratings. The proposed performance metric quantifies elements of the decision-making process by 1) evaluating the distance between ratings reported by the modeller and the actual outcome or the modellers 'true' beliefs, 2) providing an indication of "good" ratings, 3) accounting for the context and the forecasting difficulty to which the ratings are being applied, and 4) capturing the introduction of any subjective human bias within human-based rating systems. The metric is shown to outperform conventional model evaluation metrics such, mean square error, root mean square error and mean absolute error, in specific forecasting scenarios of varying difficulty. The application of the performance metric is not restricted to the evaluation of human-based ratings and is applicable in any field where an evaluation between the actual and predicted outcome is required.

# OBITUARIES

## Sir Vaughan Frederick Randal Jones, 31/12/1952 – 6/9/2020

### Introduction

Vaughan Jones, KNZM, DSc (Geneva), MSc (Auckland), FRS, died unexpectedly after a brief illness at his home in Nashville, Tennessee, USA, on 6 September 2020.

Vaughan was (and still is) undoubtedly New Zealand's most celebrated mathematician. Amongst his numerous awards were the Fields Medal at the Kyoto International Congress of Mathematicians in 1990, honorary doctorates from the University of Auckland (1992), the University of Wales (1993) and Université du Littoral Côte d'Opale (2002), various other medals such as the first NZ Government Science Medal (later renamed the Rutherford Medal)[6] and the Onsager Medal of Trondheim University, and fellowships or honorary fellowships of the Royal Society, the Royal Society of New Zealand, the Australian Academy of Sciences, the American Academy of Arts & Sciences, the US National Academy of Sciences, the Norwegian Royal Society of Letters and Sciences and the London Mathematical Society, as well as a recent International Cooperation Award from China.

Born in Gisborne on the last day of 1952, Vaughan completed his primary education at St Peter's School in Cambridge, attended Auckland Grammar School 1966–69, and the University of Auckland 1970–73, graduating MSc with first class honours. He then attended the Université de Genève, initially in Physics but later transferring to Mathematics, and completing his Docteur des Sciences degree with a thesis entitled *Actions of Finite Groups on the Hyperfinite* $\mathrm{II}_1$ *Factor*, under the supervision of André Haefliger.

One of us got to teach Vaughan his first course in Analysis (and later taught a course in Knot Theory that Vaughan did not enrol in, so cannot claim help in the discovery of the Jones polynomial). Since Vaughan's death, however, it has been revealed that another member of the outstanding Masters class of 1973 shared some of the ideas from the course with Vaughan, and together they showed that the Alexander polynomial could not be used to distinguish the square and granny knots. On the other hand, the Jones polynomial can distinguish these two knots quickly. Like many top students of his age, Vaughan was torn between Mathematics and Physics, but he said that the Mathematics course that most influenced him at Auckland was a course in Functional Analysis, taught by the late Michael Lennon. Michael himself as a student at Auckland (ten years earlier) had faced the same conflict, so his lectures on Functional Analysis would have emphasised the close links with Physics.

Following a few months as a Junior Lecturer at Auckland, Vaughan benefitted from some advice by Paul Hafner which led him to Geneva on a Swiss Government Scholarship and a F.W.W. Rhodes Memorial Scholarship. There

[6] There is a story relating to this medal. As its first recipient, and not in New Zealand much of the time, a hastily arranged ceremony took place, with the Prime Minister awarding Vaughan a cardboard medal and the promise of the real thing to come once it was designed. A couple of years later Vaughan mentioned this to one of us and commented that he had never received the 'real' medal. So a letter was duly sent to the Prime Minister expressing strong approval of the new award, but regret that the real medal was still not forthcoming. Apparently it was still being designed, and eventually the cardboard medal was replaced by a gold-plated one.

he won the Vacheron Constantin Prize for his doctoral thesis. Then followed a number of short appointments in the USA, first as E.R.Hedrick Assistant Professor at UCLA, Los Angeles (1980–81), then Visiting Lecturer, Assistant Professor, and Associate Professor at the University of Pennsylvania (1981–84), supported in part by an Alfred P. Sloan Research Fellowship. He spent a large part of his career as a Professor of Mathematics at the University of California, Berkeley, from 1985 to 2012, and then as Stevenson Distinguished Professor of Mathematics at Vanderbilt University, Nashville, Tennessee, where he remained until his death. From 1992 until his death he also had a part-time appointment as a Distinguished Alumnus Professor at the University of Auckland.

Later in the 1980s, no doubt along with others, a group of mathematicians in New Zealand put together a case for Vaughan to be considered for the award of a Fields Medal, and this was successful. It was a particular triumph as the first Fields Medal to be awarded to a mathematician born in the Southern Hemisphere. (Well, one of us started the rumour 30 years ago and nobody seems to have refuted it!). Many other honours followed.

Of particular importance for New Zealand was a suggestion by the late Professor Roy Geddes, as Dean of Science at the University of Auckland, that we propose some sort of position for Vaughan at the University of Auckland. Following correspondence with Vaughan about possibilities, a case was put to the Vice-Chancellor, Sir Colin Maiden, who immediately agreed to appoint Vaughan as a Distinguished Alumnus Professor, with Vaughan's preference to make a contribution to the wider New Zealand mathematics community being accepted as his duties.

Following this appointment in 1992, discussions began for the first of the Summer Mathematical Research Workshops. There wasn't a lot of money for that first one, which took place in Huia (to the west of Auckland) in December 1994, but it was a resounding success. Those workshops have continued in January every year since 1996, and around various parts of New Zealand. Vaughan attended every single one of them, and made major contributions by encouraging outstanding mathematicians to contribute lectures, lecturing himself, working hard to ensure that the lectures adhere to the principle that they should take graduate students from where they are to understanding at least some of the frontier of research in the field, teaching participants how to wind-surf, and taking charge of the barbecue at the end of the week. During breaks between talks, Vaughan could be seen talking to a wide range of participants, making even the most timid student feel an important part of the proceedings. To oversee the workshops, together with us four he established the New Zealand Mathematics Research Institute (Inc.), and Vaughan served as chair of its directorate from its founding in 1998 until 2020.

Growing out of the NZMRI was one of the first NZ government-funded Centres of Research Excellence, the New Zealand Institute for Mathematics and its Applications. This operated from 2002 until 2012, was co-directed by Vaughan Jones and Marston Conder, and involved a large proportion of the leading pure and applied mathematicians and statisticians from across NZ. The NZIMA's vision was to become one of the world's leading research institutes in the mathematical sciences, known nationally and internationally for high quality fundamental research, for innovative and beneficial application of mathematical, statistical and computational techniques, for engagement with relevant communities, and for nurturing the next generation of mathematicians.

The NZIMA supported thematic programmes in a model along the lines of similar institutes around the world, benefitting a large number of mathematicians and statisticians across all of New Zealand, overcoming initial skepticism that it might concentrate its resources narrowly. In fact, in line with Vaughan's vision, the NZIMA was aimed at developing mathematical talent right across New Zealand. Despite having superb reviews by international evaluations, and arguably being the strongest of the CoREs at the time, paradoxically it did not win re-selection as a CoRE, when judged as being "no greater than the sum of its parts". There is no doubt that along with the NZMRI, the NZIMA played a major role in helping the mathematical sciences lift their performance in New Zealand, to sit among the top-ranked subject areas in the last two PBRF Quality Evaluations in 2012 and 2018.

**Vaughan Jones' Research Highlights**

What follows is a brief sketch of some of Vaughan's remarkable research contributions. To any reader interested in delving more deeply into any of these areas, we recommend starting with Vaughan's own papers which are easily found. Vaughan Jones was among the most original mathematicians of the last few decades. In the 1980s he discovered entirely new types of *symmetry*, manifesting itself at the deepest quantum levels, and subsequently influencing both pure and applied mathematics. His ground-breaking discoveries led him to create *Subfactor Theory*, and to develop with it a revolutionary approach to *Knot Theory* and 3-*dimensional manifolds*, through completely novel sets of invariants and associated mathematical structures.

Within just a few years of that, Vaughan's newly developed framework and invariants led to the solution of a plethora of longstanding conjectures in knot theory and low dimensional topology, some of which were over 100 years old. His work has been *extraordinarily influential*, both revolutionising some fields and bringing together others, from von Neumann algebras to braid groups, knot theory and 3-manifold invariants, from category theory, algebra and combinatorics to quantum computing, statistical mechanics, algebraic quantum field theory and mathematical biology.

**Theory of subfactors**: In 1982 Vaughan discovered an astonishing phenomenon in the theory of von Neumann algebras (*Invent Math.*, 1983). He proved that if $N \subset M$ is an abstract inclusion of von Neumann factors with a trace, then the Murray-von Neumann dimension of $M$ as an $N$-module, which is a number that he called the *index* of $N$ in $M$ and denoted by $[M : N]$, takes values in the set $\{4\cos^2\pi/n \mid n \geq 3\} \cup [4,\infty)$. By proving this striking result, Vaughan laid down the basis of a new theory, now called the *Theory of Subfactors*. His actual construction of subfactors of index 4 $\cos^2\pi/n$ constitutes by itself the discovery of an altogether new set of *symmetries* in mathematics. Composition (or *fusion*) of such symmetries gives rise to a completely new type of mathematical *group-like objects*, which are now recognised to naturally occur in many areas of mathematics. These are discussed below.

One of the most innovative techniques Vaughan introduced on this occasion is the so-called *iterated basic construction*, a purely operator algebraic procedure which associates with $N \subset M$ a whole tower of inclusions $N \subset M \subset M_1 \subset ...$, together with idempotents $e_1, e_2, ...$ which satisfy relations reminiscent of the Hecke algebra relations. In more modern terms, this translates into the fact that an inclusion $N \subset M$ can be described as a crossed product type inclusion $N \subset N \times \mathscr{G} = \mathscr{M}$, with $\mathscr{G}$ being a new kind of group-like object (of symmetries) acting on $N$. These objects $\mathscr{G}$ are now called the *standard invariants*, and have an extremely rich combinatorial structure, generalising finitely generated discrete groups, compact Lie groups, homogeneous spaces for finite groups, Hopf algebras and all of the interesting quantum groups. Results of Vaughan's work in 1983-1984 have shown that these objects have a Cayley-type graph and encode generalised Yang-Baxter equations (many not covered by "classical" quantum groups). They give rise to remarkable representations of the braid groups. After an initial axiomatization by Popa (*Invent Math.*, 1994), these standard invariants have been given several alternative interpretations. It was Vaughan who produced the last unifying description of these group-like objects (in the early 2000s) as so-called *planar algebras*, a very powerful framework for concrete computations, from which a plethora of new knot invariants and solutions to Yang-Baxter equations emerged.

The "irreducible" group-like objects $\mathscr{G}$ appearing this way have an extremely complex structure, their classification resembles the classification of simple finite groups, but it is far more complicated. Those $\mathscr{G}$ having index $\leq 4$ were already classified by 1994, as a result of the work of Jones, Popa, Ocneanu, Izumi and Kawahigashi: for index $< 4$, they correspond to Coxeter graphs $A_n, n \geq 2$ (one of each); $D_{2n}, n \geq 2$ (one of each); $E_6$ and $E_8$ (two of each); while for index $= 4$, they correspond to extended Coxeter graphs $E_6^1$, $E_7^1$, $E_8^1$ (one of each); $D_n^1$, $n \geq 4$ ($n-1$ of each); $A_\infty, D_\infty$ (one of each). During the last ten years, as a result of a tremendous effort by Vaughan and a whole team of young collaborators, this classification has been extended to cover all $\mathscr{G}$ for index $\leq 5$. This amazing work is contained in many striking papers, culminating with a beautiful 45-page survey by Jones, Morrison and Snyder, in the Spring 2014 issue of the *Bulletin of the American Math. Society.*

**Knot theory**: Shortly after his initial work on subfactors, Vaughan discovered that the iterated basic construction and the standard invariants contain a representation of the braid groups that was previously unknown. Then, in one of the most surprising and ground-breaking discoveries of the last 50 years, he realised that this braid group representation, when taken together with the trace of the ambient von Neumann factors, gives rise to a polynomial which is invariant under the Reidemeister moves of the knots represented by the corresponding braid group elements (*Bull. AMS*, 1985). Hence this polynomial is a knot invariant! In fact within a period of a few days in September/October 1984, the Editors of the *Bulletin of the American Math. Society* received four research announcements each describing the same result: a two-variable polynomial for knots and links that generalised both the Alexander and Jones polynomials.

Vaughan's work in both type $\text{II}_1$ factors and his newly discovered polynomial had reached the wider world, and quickly knot theorists from across the USA and UK had realised that the skein relations for the two different polynomials had a common generalisation. The Editor's note introducing the paper *A new polynomial invariant of knots and links* by P. Freyd, D. Yetter; J. Hoste; W. B. R. Lickorish, K. C. Millett; and A. Ocneanu in *Bull. AMS* 12 (1985), 239–246, is well worth reading. Already in his historic paper, Vaughan was able to derive several surprising applications of his invariant to knot theory. He later proved that the knot invariant is also related to Hecke algebras and their representations, thereby deriving a very simple, conceptual proof of the 2-variable HOMFLY polynomial invariant for knots, which generalised what is now called the 'Jones polynomial'. His article on this in *Annals of Math.* 126 (1987) was recently found to be the most cited article in the *Annals* since the Index-paper of Atiyah and Singer.

A couple of years later, Kauffman gave an alternative diagrammatic description of Vaughan's polynomial, which enabled him and Murasugi to solve several of the Tait conjectures in knot theory. Hence a whole new era in knot theory began with the birth of the Jones polynomial. In particular, the 'complete' Tait conjecture on alternating knots was solved by Thistlethwaite and Menasco using very complicated topological arguments, with the Jones polynomial playing a critical role. Several further questions posed by Vaughan, such as the one about finding a knot with trivial Jones polynomial, continue to be the driving motivation in this newly developed branch of knot theory.

**Three-manifolds**: Edward Witten (who also won a Fields Medal in 1990) extended the Jones polynomial and the accompanying theory to 3-manifolds . This followed a suggestion by Vaughan, popularised in notes from a talk at Atiyah's seminar in 1986, namely that the place to look was in quantum gauge field theory. The values of the parameters for which Witten's theory works are precisely the values of interest for subfactors of finite depth! Reshetikin and Turaev have clarified and generalised these discoveries, and Ocneanu has shown that any finite depth subfactor gives a topological quantum field theory (TQFT) in 3 dimensions. The simplest proof of the existence of the Witten invariant (essentially due to Lickorish) is based on the special properties of the 'Jones-Wenzl idempotent', already proved in Vaughan's original subfactor paper. Also the 'volume conjecture' made by Kashaev, Murakami and Murakami is a wonderful example of the influence of Vaughan on knot theory/physics. Based on physical intuition, it was argued that the growth rate of the limit of the coloured Jones polynomial as the number of colours goes to $\infty$ is given by the hyperbolic volume of the knot complement. This conjecture has been verified for some families of knots, but is known to be quite delicate, requiring subtle analysis to evaluate the limits, even when direct calculation is possible. A large number of people work on this topic, with conferences devoted solely to it.

**Category theory and Khovanov homology**: The appearance of Vaughan's braid group representations in a group-like structure led immediately to the discovery of braided tensor categories (by Joyal and Street), which were subsequently investigated by mathematicians and physicists throughout the 1990s (including Longo, Fredenhagen, Frolich, Kawahigashi, M. Izumi, and so on). More recently, the work of Khovanov on 'Categorification of the Jones polynomial' gave general knot invariants by doing a category-based skein theory. In fact Khovanov managed to interpret the Jones polynomial as a homology invariant (namely the Euler characteristic of an associated homology). This *Khovanov homology* approach led to other spectacular developments in recent years, including a new proof (by Rasmussen) of Thom's conjecture on the un-knotting number of a link, which was initially proved by Gauge theory techniques. Also Dror Bar Natan showed that Vaughan's planar algebras are the right language to use in calculating Khovanov homology. He gave a slightly more abstract definition of Khovanov homology, as a planar algebra in an appropriate sense, and because of this, it can be calculated much more rapidly than the original Khovanov homology, even though it is more powerful.

**Braid groups**: Given the impact of Vaughan's work, it is hard to imagine nowadays how the theory of braid groups and their representations was before 1984. It was a relatively obscure field, and Vaughan sometimes talked about how little interest there was in it when he found his braid group representations. After the Jones polynomial appeared, however, his discovery of the braid group representation in the tower of subfactors (1982) stimulated significant new interest in braid groups and the discovery of many many other braid group representations. In 2000/2001, Bigelow and Krammer (independently) proved that a particular one of these representations is faithful, so that the braid group is linear (and reported this in ICM 2002 invited talks). A still-unsolved major problem in this field asks whether or not Vaughan's original representation in the Temperley-Lieb algebra is faithful.

**Knots and links from the Thompson groups**: During the last few years, Vaughan developed an original procedure for constructing actions of groups of fractions of certain categories. A striking application of his method concerns the Thompson groups F, T and V, which he was able to realise as groups of fractions of categories of forests, thus finding new actions of these groups on many spaces. By representing the category of forests on Conway tangles, he obtained constructions of knots and links from F and T, and showed that any link can be obtained in this way. Also using TQFT, he obtained from this a very interesting new class of unitary representations on Hilbert space, whose coefficients are the TQFT link invariants! This work has been received with a lot interest (and surprise) by the group theory community and other people working on the Thompson groups.

**Algebras**: Vaughan's approaches and discoveries have become extremely powerful in many areas of mathematics, and a notable example is in Wenzl's proof of the semisimplicity of the Brauer algebra (1989). The lure of a knot invariant and braid representations provided crucial motivation for people who developed quantum groups, in particular the study of the centralizer algebras. The Temperley-Lieb algebra (more correctly now called the Jones-Temperley-Lieb algebra), which describes the algebraic relations between the Jones idempotents in the standard invariant, has become very popular in algebra. The annular Temperley-Lieb algebra discovered by Vaughan in the mid-1990s (see *l'Enseign. Math.* vol. 38 (2001)) has been studied by a lot of people following Vaughan's work. All of this culminated in his discovery that the standard invariants have a *planar algebra* structure, whose description involves a mixed category/operad structure.

Vaughan's diagrammatic approach to the study of these amazingly rich group-like objects provided a totally new vision of the structure of subfactors. By organising planar pictures in simple ways, some powerful new techniques have been developed for the construction of subfactors and restrictions on their possible invariants, akin to (but much more difficult than) the classification of simple Lie algebras via Coxeter-Dynkin diagrams. Using planar algebras, he and Bisch made a plethora of new discoveries about obstructions on the graphs of subfactors, and on the classification of standard invariants of small dimension. As noted above, the importance of these goes far beyond subfactor theory.

To emphasise the broad impact of Vaughan's work in other fields, we also include the following snippets.

**Combinatorics**: Vaughan's work led directly to a revival in the study of the Tutte polynomial of a graph, and a generalisation of it to signed graphs. It has been shown that computation of the Jones polynomial at almost all values is NP-complete. Another important connection with combinatorics is Jaeger's discovery of a spin model knot invariant based on the Higman-Sims graph, which grew out of an attempt by Pierre de la Harpe and Vaughan to obtain spin models for the Kauffman polynomial.

**Algebraic quantum field theory**: Following Vaughan's breakthrough on subfactors and braid groups in the 1980s, several groups of people (including Frolich, Longo, Roberts, Fredenhagen and Rehren Schroer) noticed a striking connection with the Doplicher Haag and Roberts theory of super-selection sectors. They applied Vaughan's results to super-selection theory in low dimensions, Anyons, the fractional quantum Hall effect, and high temperature superconductivity.

**Conformal field theory**: That the Jones representations of the braid group occur as monodromy in the Wess-Zuminon-Witten model was a startling result of work by Tsuchiya and Kanie. A construction by Vaughan and Wassermann in the early 1990s led to a beautiful direct connection between the theory of subfactors and conformal field theory (CFT). This newly developed area is now pursued by many people (including Wassermann, Longo, Kawahigashi, M. Izumi, F. Xu, and others). Some spectacular discoveries have been made recently in this direction, including new insights into monstrous moonshine, notably by Longo-Kawahigashi (*Annals of Math.* 2004) and Kac-Xu.

**Random matrices**: It was shown by 't-Hooft that in the large $N$ limit for a $U(n)$ gauge theory, the only Feynmann diagrams that contribute are the planar ones. This was adopted as a systematic idea in the study of large random matrices, and it is now becoming apparent that the appropriate language to use in this field is that of Vaughan's planar algebras. If one uses a potential that is in a certain planar algebra, then the partition function (in the large $N$ limit) as well as all expected values lie in the planar algebra. Using these ideas, Vaughan worked with Guionnet and Shlyakhtenko to make connections between free probability, random matrices and von Neumann algebras, and in particular, to construct natural matrix models where the number of matrices is a continuously varying parameter.

**Quantum computing**: Mike Freedman and his Microsoft group have shown that calculation of the Jones polynomial is a universal problem for quantum computing, and proposed building a machine based on Chern Simons field theory. It is quite remarkable that they use Vaughan's original subfactor positivity of the traces (and especially $4\cos^2\pi/5$), as they need the underlying Hilbert space structure. Microsoft is testing materials which can 'reproduce' braid group statistics that bear Jones representations. Vaughan himself wrote an article with Aharanov and Landau showing how to approximate the Jones polynomial using a (conventional) quantum computer.

**Mathematical Biology**: The Jones polynomial has been very useful for molecular biologists, in solving some of the knotting and linking problems for DNA molecules. These scientists now use the Jones polynomial and related polynomials to help them understand DNA recombination mechanisms, on a regular basis.

**Acknowledgement.** The authors would like to thank Sorin Popa for help in writing this article.

*Marston Conder, Rod Downey, David Gauld and Gaven Martin; Founding Co-Directors of the NZMRI*

# REPORTS ON EVENTS

## WMAM 2020 Report

The 2020 Wellington-Manawatu Applied Mathematics conference was held at the Kelburn campus of Victoria University of Wellington (VUW) on Wednesday 4 Nov from 9:30 to 4:45. Morning tea, lunch and afternoon tea were offered to the 30 participants who attended in person in a tutorial room in the Old Kirk building, free thanks to a grant from ANZIAM NZ Branch. A big contingent drove down from the Palmerston North campus of Massey University (PN), and we luxuriated in the opportunities for old-fashioned face-to-face discussions during the day.

The meeting opened with a reminder of the Code of Conduct, adapted from the ANZIAM code.

Dimitrios Mitsotakis kicked things off with a presentation on modelling tsunamis, and the invited speakers were Amanda Hampton (University of Colorado), Nicholas Witte (VUW), Sishu Muni (PN), Robert McLachlan (PN), Virginia Listanti (VUW), and Alex Simpson (VUW). Some photos taken during the conference appear in this report, and more may be found at the dropbox link:

https://www.dropbox.com/sh/1yp6xht9cnpslcz/AABaqpJ26KmqmEyDJ1VgkE8Da?dl=0

Many of us were able to stay a little longer after the conference, and walk around the corner to the Hunter Lounge on campus where there was live coverage of the American election results, a huge range of pizzas, curly fries, loaded fries, a range of convivial beverages, and again the luxury of in-person conversations.

We are so grateful to our sponsors, ANZIAM NZ Branch and the School of Mathematics and Statistics, Victoria University of Wellington, as well as our wonderful people in the School Office who organised all of the food and tea and coffee and orange juice during the day.


*Mark McGuinness*

# GENERAL NOTICES

## IMO results for 2020

It is with great pleasure that I inform you of the IMO results for 2020. Congratulations to all 6 team members who each solved at least one question [out of six]. New Zealand was ranked 47th with a total score of 102 points.

We also have a gold medalist (Ishan Nath) who was ranked equal 19th in the world with a final score of 35 [out of a possible 42]. This is only the second time a NZ student has won gold in our 33 years of participation in the IMO.

This year's IMO is unique, as a distance event. The usual format IMO was scheduled for St Petersburg in July, but it was cancelled due to CoVID-19, and replaced by a simultaneously held distance event. NZ being the eastern most participating country had to take the IMO exams from 7:30pm to midnight [local time], on two successive days in mid-September.

Detailed results have been published here: https://www.imo-official.org/country_individual_r.aspx?code=NZL. Reports from the New Zealand team can be found here: https://www.mathsolympiad.org.nz/news/reports/

*Ivan Reilly*

When dreaming of eventually participating in an IMO, I must say I never expected my eventual experience to be anything like what it was. Not only was I unable to meet hundreds of students with unique backgrounds and stories, spend time living in a cramped room with the whole team or finally figure out how Ross, our team leader, maintained his half-beard, I was also unable to even train in person with the full New Zealand team. But yet through all of the changes, the core experiences which I imagined I'd encounter in the International Mathematical Olympiad - the sense of pride and patriotism, the appreciation of and friendships with my fellow team members and most importantly the difficult problems - were still there.

Nathaniel Masfen-Yan

Notably, I would especially like to acknowledge Josie and Ross who did a great job of ensuring the team had regular online lectures and problem sessions in the months prior to the IMO so that we were both prepared for the exam and maintained connections with all of the members of the team. This and the work of the NZMOC and IMO committee in organising the competition itself meant that I was able to leave high school still feeling like I had an IMO experience, even if it was one conducted mostly through my laptop.

*Nathaniel Masfen-Yan*

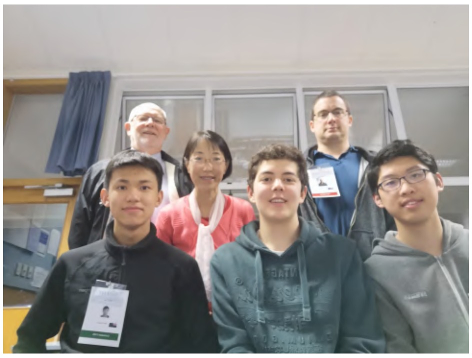

**Figure 1:** IMO participants Rick Han, Nathaniel Masfen-Yan and Philip Han (bottom row left to right) and invigilators Ivan Reilly, May Meng and Gabriel Verret (top row left to right)

# NZMS NOTICES

## Draft minutes of 46th Annual General Meeting of the NZMS

Virtual meeting hosted by AUT (via MS Teams), 1st December 2020.

**Present:** Boris Baeumer, Alona Ben-Tal, Florian Beyer, Richard Brown, John Butcher, David Bryant, Jiling Cao, Lisa Orloff Clark, Marston Conder, Graham Donovan, Luke Fullard, Steven Galbraith, Rod Gover, Marie Graff, Shaun Hendy (chair), Astrid an Huef, Joerg Hennig, Sam Irvine, Stephen Joe, Vivien Kirk, Carlo Laing, Woei Chet Lim, Michael Lockyer, Tammy Lynch, Stephen Marsland, Gaven Martin, Mark McGuinness, Robert McLachlan, Jeanette McLeod, Rua Murray (minutes), Eamonn O'Brien, Mike Plank, Claire Postlethwaite, Iain Raeburn, Mick Roberts, Jeroen Schillewaert, Dominic Searles, John Shanks, David Simpson, Kerri Spooner, Catherine Hassell Sweatman, Winston Sweatman, Melissa Tacy, Steve Taylor, Tom ter Elst, Christopher Tuffley, Alna van der Merwe, Geertrui Van de Voorde, Graeme Wake, Phil Wilson, Wenjun Zhang

**Apologies:** Sina Greenwood, Emily Harvey, Fabien Montiel.

Meeting opened: 2.20 pm.

1. Minutes of the 45th Annual General Meeting were accepted.
   (Moved from Chair, passed.)

2. There were no matters arising.

3. *Vaughan Jones, in memoriam.* Prof Sir Vaughan Jones, New Zealand's most celebrated mathematician, died tragically this year following a short illness. Prof Marston Conder gave a tribute to Vaughan, noting his Fields medal in 1990, and numerous international and New Zealand honours, including a Knighthood. Vaughan was widely known as a generous friend and colleague. His efforts raised the profile of mathematics in New Zealand, as well as New Zealand mathematics internationally.

4. *President's verbal report.*
   Prof Hendy noted that 2020 has been a very hard year, dominated by the Covid-19 pandemic. The Society's business included fallout from proposals to restructure Massey Sciences, with likely loss of jobs of mathematicians. The Society has made submissions on two iterations of proposals, as well as public comment. These developments are particularly distressing in the light of the significant contribution that mathematics has made to the country this year.
   Prof Hendy also noted the disproportionate impact that Covid-19 related disruptions are having on early career researchers: honours and masters students are unable to take-up doctoral positions abroad; there is a loss of inflow of overseas graduate students; uptake of postdoctoral positions has been severely limited; beginning faculty without permanent jobs have been at the frontline of position cuts.
   Prof Hendy emphasised and commended the work that Melissa Tacy has been doing to support the ECR mathematics community.
   The President concluded his report by thanking Immediate Past President Vivien Kirk, and Secretary Rua Murray for picking up a significant portion of the President's workload in 2020. He then announced his intention to step down as President as a result of the demands associated with his ongoing commitments to the mathematical modelling that will continue to support the national Covid-19 response in 2021.

   A member thanked the Society, and the President in particular, for the support of Massey staff.

   The meeting then accepted the President's report, by electronic ballot.

5. *Treasurer's report.* The report was taken as read, with the Treasurer emphasising that budgets were underspent in 2020 due to Covid-19 related disruptions to student conference travel. Income from the Society's interest bearing investments is falling due to low interest rates. The Treasurer's report was accepted. (Moved from Chair, passed by electronic ballot.)

6. *Appointment of auditors.* The current auditor, Nirmala Nath from the School of Accountancy, Massey University, to be re-appointed as Auditor. (Moved from Chair, passed by electronic ballot.)

7. *Membership Secretary's report.* This was presented (as tabled) and accepted. (Moved from Chair, passed by electronic ballot.)

   2020 fees to remain unchanged for 2021. (Moved from Chair, passed by electronic ballot.)

The AGM recorded its thanks to John Shanks for his ongoing service as Membership Secretary. (Moved from Chair, passed by electronic ballot.)

8. *Election of Incoming President and Councillors.*

   (a) Departing Councillors: the following Council members have completed their terms:
   - Florian Beyer — Otago (2014–2020)
   - Kevin Broughan — Waikato (2017–2020)
   - Vivien Kirk — Auckland (Immediate Past President)
   - Rua Murray — Canterbury (2014–2020)

   (b) Incoming Vice-President: Prof David Bryant is the only nominee (nom: Boris Baeumer, Vivien Kirk), and is declared elected.

   (c) Election of Councillors: an election was held for three vacant Council positions. The nominees were:
   - Stephen Joe — Waikato (nom: Woei Chet Lim, Kevin Broughan)
   - Bernd Krauskopf — Auckland (nom: Vivien Kirk, Claire Postlethwaite)
   - Dominic Searles — Otago (nom: Florian Beyer, Melissa Tacy)
   - Geertrui Van der Voorde — Canterbury (nom: Clemency Montelle, Miguel Moyers–Gonzalez)

   The ballot was conducted by anonymous poll in MS Teams, with Michael Lockyer and Rua Murray acting as returning officers. Bernd Krauskopf, Dominic Searles, Geertrui Van der Voorde were elected.

   (d) The President and Secretary explained to the meeting the consequences of a resignation from the Presidency, as detailed in the Society's constitution. In these circumstances, the Vice-President becomes President until the next AGM and the Council appoints a replacement Vice-President. The term of that Vice-President lasts until the next AGM. Normally, the Vice-Presidency would pass from the Immediate Past President to the Incoming Vice-President immediately after the AGM at which the Incoming Vice-President is elected. The constitution does not specify the course of action to be followed when the Presidency and Vice-Presidency become vacant simultaneously on the date of the AGM. The principles implicit in the constitution suggest that the newly elected Incoming Vice-President becomes President, and that Presidency should last for two years. The Council intends to resolve the situation by Prof Bryant immediately assuming the Presidency, the Council appointing a Vice-President, and the next AGM electing a new Incoming Vice-President (after one year). These actions will allow the normal cycle codified in the constitution to be restored. There is no provision in the constitution for the AGM to elect either an interim President, or a Vice-President other than as Incoming Vice-President (who would then become President after one year).
   Prof Hendy indicated the Council's intention to appoint a Vice-President from among the elected Council members. This will create a vacancy in the Council, which the Council can fill by cooption. In these circumstances, the Council prefers to coopt the remaining nominee for regular Council membership, following the election in part (c).

9. *Forthcoming colloquia:*

   **2021** 7-9 December, Canterbury.

   **2022** VUW.

   **2023** Joint AMS/NZMS/AustMS meeting. This was planned for Auckland to host (4-8/12/23). However, preliminary organisational steps have been stalled due to the Covid-19 pandemic, and it is presently unclear whether the meeting will go ahead on the planned timeline.

10. Julia Wolf's 2020 Forder tour was cut short by the deteriorating global situation due to Covid-19, and she returned to the UK in March. It has been agreed with the LMS that all future Forder and Aitken lecturerships will be deferred by one year.

11. The report for the NZJM report was accepted. (Moved from Chair, passed by electronic ballot.)

12. Correspondence (none)

13. General business: Several members had raised for discussion the issue of the requirement for all authors of a paper nominated for the Kalman Prize to provide CVs. Papers attached to the agenda were taken as read. Members were invited to communicate any views on matters raised to the Council (via the Secretary). The incoming Council will review processes for the Kalman Prize prior to the call for nominations in 2021.

    A member noted Professor Hendy's service over the last two years, particularly his leadership on the responses to the Massey restructuring. Members in general, and the Council in particular, thank him for his service.

    *Motion:* "The AGM records its thanks to the outgoing Council members, especially Immediate Past President Vivien Kirk." (Moved from Chair, passed by electronic ballot.)

Meeting closed 3.14 pm.

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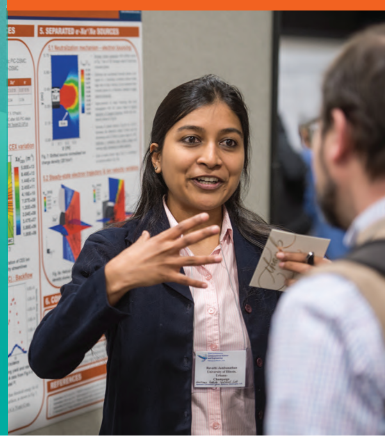
— Lisa Fauci
*Professor of Mathematics, Tulane University, U.S.*



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