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

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EDITORIAL

Welcome to the first newsletter for 2021. As a society we welcome a new President, David Bryant, who has stepped in early to replace Shaun Hendy whose time had been dominated by COVID modelling. In his column David ask the question "who is the NZMS for" and provides some of his ideas on the answer.

We also welcome all newly-elected and returning members of the NZMS council and thank them for the service they provide for our community. In particular, Graham Donovan takes on the role of vice-president and Phil Wilson (past editor of the newsletter) is our new secretary. Phil has some exciting announcements in this newsletter (see Notices below), with the dates of the 2021 NZMS Colloquium, which will be held *in-person*, and the return of Maths Craft.

The COVID pandemic still dominates both international and domestic life, however we all hope that the unrolling of vaccines both here and overseas will have a positive impact. As we write this column the trans-Tasman bubble is opening up as a two way green corridor of travel. For many members of the NZMS this opens the possibility of resuming personal and professional contacts in Australia. For others who have been waiting in Australia to take positions in New Zealand: welcome, we are glad to finally get you here!

Finally, we (Melissa and Fabien) have decided that 2021 will be our last year as co-editor of the newsletter. We have enjoyed this role very much for the last 2 years. It has allowed us to connect with many members of our community and share their stories in various formats. We will surely reflect on our experience in the coming months and report our findings in the next 2 newsletters. In the meantime, we are actively looking for a person or team to take over the role of editor of the newsletter. As we have proved this last year, a multi-institutional team of co-editors works. This is a fantastic opportunity for anyone looking at contributing to the smooth running of our society and with the help of all our regular and dedicated contributors, this is an enjoyable and rewarding exercise. If this sounds like something you would like to do, please get in touch with us or any members of the council.

Fabien Montiel and Melissa Tacy

PRESIDENT'S COLUMN

I became president of the NZMS last December, taking over from Shaun Hendy at fairly short notice to allow him more time to devote to essential COVID modelling. Usually, an incoming NZMS president has a whole year as vice-president to master the intricacies of society administration. In my case, the transition from member to vice president to president was all over in a matter of minutes. Be warned — it could happen to you one day.

Much of my summer was spent figuring out how the society works. I treated it as a research project, and like any research the key step is figuring out which question to ask. For me it was "what is it all for?". What is the NZMS actually for? We give prizes to ourselves, and put on an excellent colloquium. Some of us run maths craft, others produce this newsletter. But to what end?

However this is not the right question. At the risk of sounding like a TED speaker, I realised that we shouldn't ask what the NZMS is for, but rather who it is for. Debates about who the NZMS is for are not new, dating right back to the formation of the society.

The NZMS came into being at the national colloquium in 1974, however much of the legwork was done by a small committee in 1973 chaired by David Vere-Jones. The committee conducted a comprehensive survey of the country's academic mathematicians and the responses to the survey are available on our website. Some of the comments could have been written yesterday. Others make it clear just how long ago this was, like a complaint that $5 membership fees are excessive as the colloquium only costs $2!

A big divide arose when the question of target membership was considered. The committee identified two basic positions: (i) those who favour a society primarily devoted to mathematical scholarship and research; and (ii) those who favour a society concerned with a wider range of activities, including promotion of mathematics, teaching, scholarship and applications in industry and elsewhere. Position (i) suggests a more exclusive, cloistered model. Position (ii) suggests a more inclusive, externally engaged model. There are advantages and disadvantages. In my opinion, only position (ii) has a future. The early members of the society must have come to the same conclusion since the constitution aligns far more closely with position (ii) than with position (i). Officially, there are two main functions of the NZMS:

1. To promote the development, application and dissemination of mathematical knowledge within NZ.

2. To assist mathematicians in NZ to maintain effective cooperation with one another and with mathematicians and mathematical societies in other countries.

Fifty years on and I can't help thinking that the NZMS has drifted away from the idea of the broad mathematical community envisioned in the constitution. There is a definite emphasis on academics and academic things. Don't get me wrong — the NZMS is a wonderfully well-organised, well-run institution (and here I tip my hat to Shaun, Vivien and Rua as well as the many previous administrations). There has been a huge amount of hard work improving and modernising our processes, looking for ways to curb our conscious and unconscious biases, and addressing important lacks of diversity in key areas. However my view is that we now have a real opportunity to build on this work. It is time to think seriously about who actually makes up the New Zealand mathematics community that the society was set up to serve.

Clearly, the mathematics academics, postdocs, and graduate students will continue to make up a key group within the society, and always will. However I can think of at least four other groups who we should consider.

The first group are mathematics teachers, at primary and secondary level. This is the largest group of professional mathematicians in the country. Teachers are custodians of the country's future mathematicians. Neverthess it appears that there is a lot of room for strengthening the links with our teachers and educationalists. We would be wise to act quickly, as the upcoming report on mathematics education could prove horribly divisive if misinterpreted or misused. Fortunately, I also think that improving links will not be too difficult, given the excellent work of the education committee and existing relationships with the NZAMT, PMA and provincial mathematics associations. Such links are critical for making our courses and teaching practices relevant to the current generation of undergraduates.

The second group are the recreational mathematicians, those who have a love for things mathematical even if they are not working directly with mathematics in their professions. These are the people we reach with talks, magazine articles and public events. They are also likely to support us in advocacy work for mathematics as a discipline.

The third group are the mathematicians working in other academic disciplines. These are often our strongest allies, as we work to form networks, build up programs, and push back at the managerial zealots. Much of our professional work is service teaching, and these contacts will help us find relevant perspectives and examples connecting students' mathematics to their own disciplines.

The fourth group are the mathematicians working in industry, private sector and public sector. These are the people who will recognise the skills our graduates bring, and who can also help keep our mathematical programs relevant. Some care is required: many collaborators in the private sector have horror stories of over-promising academics or IP-obsessed University commercialisation offices. I think there are several excellent models overseas we could adopt, as well as some fine collaboration programs already running in NZ.

This list is by no means exhaustive. At this early stage, I don't have fixed plans for how the NZMS could best serve these, and other, mathematics communities. I've only just started talking with the council about where we could head and where we could start. However I strongly suspect there there could be scope for constructive changes in the way we think about, and run, this society. Watch this space.

David Bryant

EDUCATION

The Royal Society Te Apārangi has convened an expert mathematics panel to provide advice to the Ministry of Education. The panel will provide advice on:

- the mathematical skills and knowledge needed for being a critically engaged citizen;
- the mathematics skills and knowledge learners need to know and by when, and the important cross-disciplinary links, taking into consideration the rapid changes and growth in computer science/ICT;
- the important 'big ideas' in mathematics and statistics that all learners need to develop through schooling;
- the relationship between numeracy and mathematics.

The NZMS Education Group is pleased to see the convening of this panel and looks forward to their report. A few years ago, we spent a lot of time setting a foundational goal for our group. We feel that mathematics education in NZ should aspire to this and hope that the Royal Society expert panel helps to work towards this. The NZMS Education Group's foundational goal is:

All students should experience mathematics teaching that engenders the development of mathematical problem solving, reasoning, conceptual understanding and fluency, underpinned by confidence and competence in the skills of mathematics and statistics. Teachers and schools need to be given the systematic support and tools to make this happen.

If you want to find out more about the panel's work or views on the needed improvements, you may want to read:

1. Panel task and members:
   https://www.royalsociety.org.nz/what-we-do/our-expert-advice/our-expert-advice-under-development/mathematics-education/
2. Refreshing the National Curriculum:
   https://www.education.govt.nz/our-work/changes-in-education/national-curriculum-refresh/
3. Spinoff article written by two panel members:
   https://thespinoff.co.nz/society/09-02-2021/we-should-all-be-worried-about-new-zealands-woeful-performance-in-maths/
4. Opinion piece by a maths facilitator who works with teachers:
   https://www.waikato.ac.nz/professionallearning/blog/A-response-to-the-recent-reporting-of-the-decline-of-students-mathematics-achievement
5. Opinion piece about maths anxiety of primary school teachers in NZ and ways to improve:
   https://www.stuff.co.nz/opinion/124281883/maths-is-everywhere--so-we-need-better-ways-of-learning-and-teaching-it

Cami Sawyer

MATHEMATICAL MINIATURE

MM53: Always invert

Sometimes it is helpful to look at a mathematical question from a different viewpoint. Jacobi expressed this as the general principle that one should always invert. It is also useful in everyday life.

Many years ago an advertisement, for a brand of under-garments, claimed that the waist-band would outlast the rest of the garment. Under the "always invert" principle, this was really guaranteeing that the fabric would wear out even before the waist-band did so.

In this miniature, I will give a solution to a particular Diophantine equation and, in the appendix, I will relate this to a more widely known equation, which has a human-interest anecdote associated with it. The usual way of presenting a result like this is to give the motivational story first, but I am applying the "always invert" principle. If you show this miniature to other people, please don't tell them how it ends.

As background, you might like to think about the ring $R = \mathbb{Z}(\sqrt{-3})$ and its units and primes.

For $z = a + b\sqrt{-3} \in R$ the norm of z is defined as $\|z\| := a^2 + 3b^2$.

Lemma 1. *Let $p > 3$ be a prime number; then $z = a + b\sqrt{-3} \in R$ exists such that $p \mid \|z\|$, with $p \nmid a$, $p \nmid b$, if and only if $6 \mid p - 1$.*

Proof. Choose c so that $bc \equiv 1 \bmod p$ and let $d = ac$. By multiplying by c^2, we see that $a^2 + 3b^2 = 0 \bmod p$, iff $d^2 \equiv -3 \bmod p$, which would mean that $(-3/p) = 1$ in the notation of Legendre symbols. A calculation, which uses an example of the quadratic reciprocity theorem, gives

$$\left(\tfrac{-3}{p}\right) = \left(\tfrac{-1}{p}\right)\left(\tfrac{3}{p}\right) = (-1)^{\frac{p-1}{2}}(-1)^{\frac{p-1}{2}}\left(\tfrac{p}{3}\right) = \left(\tfrac{p}{3}\right),$$

so that if $6 \mid p - 1$, then $(p/3) = (1/3) = 1$, and, otherwise, $(p/3) = (2/3) = -1$. □

This leads to the next result whose proof is omitted for brevity.

Theorem 2. *If $6 \mid p - 1$, then unique $|a|, |b|$ exist such that $a^2 + 3b^2 = p$.*

Add to this result the special case $a = b = 1$: $\|1 + \sqrt{-3}\| = 4$.

Problem 1. *Show that R does not have unique factorization.*

Problem 2. *Find the primes of R.*

We will now consider the Diophantine equation

$$a(a^2 + 3b^2) = c(c^2 + 3d^2), \tag{1}$$

where we look for fundamental solutions; that is, solutions for which $\gcd(a,b,c,d) = 1$. We will impose the restriction $a > 0$, for convenience. A possible scheme for finding solutions is

Theorem 3. *Every solution of (1) is of the form*

$$\begin{aligned} a &= s\alpha - 3t\beta, \\ b &= t\alpha + s\beta, \\ c &= s\gamma - 3t\delta, \\ d &= t\gamma + s\delta, \end{aligned}$$

where $\alpha, \beta, \gamma, \delta$ are parameters and

$$\begin{bmatrix} r \\ s \\ t \end{bmatrix} = G^{-1} \begin{bmatrix} 3(\beta\gamma - \alpha\delta) \\ 9(\beta^3 - \delta^3) + 3(\alpha^2\beta - \gamma^2\delta) \\ \alpha^3 - \gamma^3 + 3(\alpha\beta^2 - \gamma\delta^2) \end{bmatrix},$$

where G is an integer chosen to cancel out common factors in r, s, t and to satisfy $r > 0$.

The detailed proof is omitted but, in summary, it is composed of three steps:
1. The equation (1) is replaced by $\widetilde{a}(a^2+3b^2)=\widetilde{c}(c^2+3d^2)$.
2. This is solved as an example of the Diophantine equation $AB=CD$.
3. Values of r,s,t are chosen so that $\widetilde{a}=a$ and $\widetilde{c}=c$ are satisfied.

Problem 3. *Find the solution corresponding to* $\alpha=1,\beta=2,\gamma=4,\delta=1$.

Further solutions will be listed within the appendix.

Appendix

"No," Ramanujan replied to Hardy, "it is a very interesting number; it is the smallest number expressible as the sum of two cubes in two different ways." Thus, the number $1729=12^3+1^3=10^3+9^3$ became famous.

We will look for fundamental solutions to

$$N=x^3+y^3=u^3+v^3. \tag{2}$$

For any solution of (2), there is a corresponding solution of (1) given by,

$$\begin{bmatrix}a\\b\end{bmatrix}=T\begin{bmatrix}x\\y\end{bmatrix},\quad \begin{bmatrix}c\\d\end{bmatrix}=T\begin{bmatrix}u\\v\end{bmatrix},$$

where

$$T=\begin{cases}\begin{bmatrix}1&1\\1&-1\end{bmatrix}, & x+y \text{ odd},\\ \frac{1}{2}\begin{bmatrix}1&1\\1&-1\end{bmatrix}, & x+y \text{ even},\end{cases}\qquad T^{-1}=\begin{cases}\frac{1}{2}\begin{bmatrix}1&1\\1&-1\end{bmatrix}, & x+y \text{ odd},\\ \begin{bmatrix}1&1\\1&-1\end{bmatrix}, & x+y \text{ even}.\end{cases}$$

For example, for $\alpha=\beta=1$, $\gamma=0$, $\delta=-2$, it is found that $[r,s,t]=[3,42,2]$ and $[a,b,c,d]=[9,11,3,-21]$. Although this gives $[x,y,u,v]=[10,-1,-9,12]$, it is convenient to rearrange this as $[x,y,u,v]=[10,9,1,12]$.

All solutions with $N\le 100000$ are as follows

α	β	γ	δ	r	s	t	a	b	c	d	x	y	u	v	N
1	1	0	−2	3	42	2	9	11	3	−21	10	9	1	12	1729
0	1	1	1	3	−3	−4	12	−3	9	−7	9	15	2	16	4104
2	1	−1	−1	1	11	6	4	23	7	−17	10	27	19	24	20683
0	1	2	0	6	9	−8	24	9	18	−16	33	15	2	34	39312
0	1	1	−1	3	21	−4	12	21	9	−25	33	16	9	34	40033
−2	−3	−5	−1	1	−5	2	28	11	31	−5	39	17	26	36	64232
1	2	−2	2	2	2	−5	32	−1	26	14	12	40	31	33	65728

If the number of negative values among x,y,u,v is odd, then the solution can be re-written in the form $x^3+y^3+z^3=w^3$, with only positive integers arising. These are also of interest and some sample solutions are given below. They can also be interpreted as partitions of unity as sums of three positive rational cubes. For example,

$$(\tfrac{2}{3})^3+(\tfrac{5}{6})^3+(\tfrac{1}{2})^3=1.$$

α	β	γ	δ	r	s	t	a	b	c	d	x	y	z	w
1	0	0	1	3	9	−1	9	−1	3	9	4	5	3	6
1	1	−2	1	1	1	−2	7	−1	4	5	6	8	1	9
1	0	−1	1	3	12	−5	12	−5	3	17	17	7	14	20
−1	4	1	3	3	48	−11	12	29	21	19	2	17	40	41

Problem 4. *Show that positive fundamental solutions to* $x^3+y^3=u^3+v^3$ *exist, for arbitrarily high values of* $N=x^3+y^3$.

Problem 5. *Show that positive fundamental solutions to* $x^3+y^3+z^3=w^3$ *exist, for arbitrarily high values of* w.

Further details

This is a second attempt at the subject of Miniature 9, (Hardy's taxi, $x^2+3y^2=p$ and Michael Lennon), which suffered from being restricted to a single page.

A longer version of the present miniature, including missing proofs, is available on request.

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MATHEMATICAL MISEPONYMY

Ceva's Theorem

Surely geometry is a good source of miseponymy, especially as developments took place somewhat independently in a range of countries in the earlier days and they didn't have internet.

Ceva's Theorem is named for Giovanni Ceva (1647–1734). Wikipedia records that he was a Professor of Mathematics at the University of Pisa then the University of Mantua. His speciality was geometry.

> Let ABC be a triangle and let D, E and F be points on the sides BC, CA and AB respectively (possibly extended). Then the segments AD, BE and CF are concurrent or parallel if and only if
>
> $$AF.BD.CE = FB.DC.EA.$$

In the equation above the terms such as AF represent the signed lengths of the segments. A segment from a vertex of a triangle to a point on the opposite side (possibly extended) is called a *cevian*. A median of a triangle is a special cevian and the fact that the medians are concurrent is an immediate consequence of Ceva's Theorem.

Various extensions of Ceva's Theorem have been described, including to n-gons in the plane and polyacrons: see [2] for the latter, where they recall the definition of "polyacron" introduced by T P Kirkman in the 19$^{\text{th}}$-century.

Who discovered Ceva's Theorem? The nearest I have managed to get is Yūsuf al-Mu'taman ibn Hūd. [4] begins "Yūsuf al-Mu'taman ibn Hūd, the king of Saragossa from 1081 to his death in 1085, is rarely mentioned in modern accounts on the history of mathematics." He lived, of course, about 600 years before Ceva's description of the theorem. It is said that both he and his father were exceptional mathematicians and surely this is so in the case of the son. As an aside it is also recorded that he had help in protecting his kingdom from Rodrigo Díaz de Vivar, better known as the Spanish hero El Cid and subject of numerous poems, a play, a novel, movies, operas and computer games.

One of Yūsuf al-Mu'taman ibn Hūd's significant contributions to mathematics was his work "Kitāb al-Istikmāl" (Book of Perfection). It seems that the book was not completed: in those days being king was a precarious job. Unfortunately, like so much written work from his era, only fragments remain and they are scattered around. [3] discusses the bits of it that had been located by 1986 while [4] goes into details of its contents. A summary of the sources of the contents is given at [4, pp 216–7]. Much of it comes from Euclid's "Elements" but many other identified sources are included. Obviously Yūsuf al-Mu'taman ibn Hūd wanted to make these sources more readily available to others. However, some of the propositions in the Istikmāl were listed by Hogendijk as material due to Yūsuf al-Mu'taman ibn Hūd himself or taken from unidentified sources. In that list is proposition 312.18 and this is our theorem: [4, p 235]. As Hogendijk notes, the theorem and a proof were published by Ceva in his 1678 book, [1][1].

References

[1] Ioanne Ceva, *De lineis rectis se invincem secantbus statica constructio*, Ludouici Montiæ, Mediolani (Milan), 1678.

[2] Branko Grünbaum and G. C. Shephard, *Ceva, Menelaus, and Selftransversality*, Geometriae Dedicata 65(1997), 179–192.

[3] Jan P. Hogendijk, *Discovery of an 11th-Century Geometrical Compilation: The Istikmāl of Yūsuf al-Mu'taman ibn Hūd, King of Saragosa*, Historia Mathematica 13(1986), 43–52.

[4] Jan P. Hogendijk, *The geometrical parts of the Istikmal of Yusuf al-Mu'taman ibn Hud (11th century). An analytical table of contents.*, Arch. Internat. Hist. Sci. 41(1991), 207–281.

David Gauld

[1] If you are into old books and have $9500 to spare you can grab a first edition!

PROFILE

David Bryant

Professor **David James Bryant** is the Director of Computational Modelling (COMO) at University of Otago. He is also the new NZMS president (2020—2022).

Born 1972 in Christchurch, David spent much of his early life in this city. His father, Peter, joined the University of Canterbury in the late 1960s, where he became Reader/Associate Professor in applied mathematics. It might be assumed, therefore, that David developed an early love for mathematical study; however, he insists that his real joy was playing piano, and, at a certain point, he would have been just as keen to have carved out a career as a pianist. Indeed, he won a music competition at school in Year 12, featuring on TV. Years later, I recall watching David on piano, accompanied by a saxophonist, as he entertained a large conference dinner hosted by the Institute Henri Poincaré.

David studied mathematics at the University of Canterbury. Straight after getting his BSc Hons with first class, David asked me about a possible PhD thesis on mathematical phylogenetics. I mentioned various questions concerning the combinatorics of trees, and he later told me he was convinced he could quickly solve them all using matroid theory! It turned out that matroid structures are few and far between in phylogenetics, so some of the questions required more elaborate arguments. Despite this, David did solve many of the problems posed (and those that weren't became conjectures that prompted later work). Indeed, his thesis ended up having considerable impact – it has been cited over 200 times, and results from it led to David being awarded "Best paper by a young scientist" at the International Conference in Computational Molecular Biology (RECOMB'99).

David was a delightful and easy student to supervise – he just went off and came back with a new theorem every few weeks! Sadly, however, only months into his thesis, he lost his father (and we lost a colleague) when Peter Bryant passed away suddenly.

After finishing his PhD, David was invited to the Centre de Recherches Mathématiques at Université de Montreal, Canada, for a postdoc (1998—2000) with David Sankoff, one of the pioneers of mathematical genomics and one of David's PhD examiners. David recalls being a little underprepared for this Canadian postdoc – arriving just before a major ice storm with insufficient clothing and unaware that French was the main language in Québec. From there, he moved to France for a second postdoc with Olivier Gascuel in Montpellier (2000—2001) before returning to Montreal in 2001 to take up an Assistant Professor position in Computer Science, Mathematics and Statistics at at McGill University. He later obtained tenure as Associate Professor before leaving Canada in 2005.

David's experiences in Canada also extended to its wildlife. Those of us who attended a workshop at the Banff Research Station a few years ago will never forget the moment when David and a couple of other colleagues stumbled upon a grizzly bear during a hike. One of the party had the steady nerve to turn their phone video on,

and David could later be heard in the video whispering to hiking buddies Tanja Stadler and Du Vinh the priceless line: "Don't run; it can run faster." Fortunately, all survived unscathed.

In 2005, David returned to New Zealand to join the new bioinformatics institute set up by Allen Rodrigo at Auckland University. Five years later, David moved south to take up an associate professor position in Dunedin, becoming professor a few years later. He lives there with wife Melanie and their sons Max and Jim (currently aged 12 and 10).

David's life was temporarily upended around 2009 when he was diagnosed with a rare bone tumour deep inside his hip. The initial prognosis did not look promising, and even obtaining a biopsy required a tricky 3 hours of surgery because of the inaccessible location of the tumour. Labs in NZ were unable to determine if it was malignant, so it was eventually sent to the US for expert opinion; as David puts it: "My tumour went to Harvard!" Fortunately, the tumour turned out to be benign. Although the resulting surgery to remove it left David in crutches for some months, he made a full recovery: "I was in the lucky 5%".

David has worked on a range of problem in mathematical phylogenetics – from genome rearrangement, to tree reconstruction using characters and quartet trees, and to phylogenetic networks. He has supervised 11 PhD and 8 MSc students. While most of David's research has been applied mathematics, some of it has led him more recently into areas of pure mathematics, including geometry, analysis and symbolic logic. These projects over the last 5 years have involved joint work with Paul Tupper, Andre Nies and others. David also publishes in high-ranking science journals, including a letter and article in Nature and a letter to PNAS entitled "Statistical Flaws undermine pre-Columbian chicken debate."

David's highest-impact discovery sprang from a collaboration with another mathematician (Vincent Moulton, a mathematics professor in Norwich). The pair developed a novel mathematical way for biologists to represent evolutionary signal using networks (rather than just trees). The method is called NeighborNet and it is widely used for representing and visualising evolution on many scales – from resolving difficult questions about how animals arose at the Cambrian explosion, to the classification of present-day infectious bacteria and viruses (including SARS-CoV-2), the evolution of languages, and applications far beyond biology (including an amusing paper published in PLoS One that used NeighborNet to classify the many different versions of the fairytale "Little Red Riding Hood"). David said the hardest part of the NeighborNet project was formally proving that the method does what it should (i.e. establish combinatorial consistency), which took several years. The 2004 paper that described NeighborNet has been cited 1800 times, and a more general paper with Daniel Huson on phylogenetic networks 2 years later has been cited 6880 times.

In 2019, David was elected fellow of the Royal Society/Te Apārangi. He is also director of the company Bayesian Demography Ltd together with his brother John, and has started working on improved computational techniques and algorithms for large-scale demographic analysis.

David's list of other ongoing and up-and-coming projects includes: convex geometry and diversities, tensor decomposition and diffusion approximations for efficient inference under multi-population models, evolutionary genetic modelling for micorrhizal fungi, and improved algorithms for evaluating the likelihood of a phylogeny.

On top of this is his role as the new NZMS president, for which David is looking at spending a year planning and then a year making some changes, promising that "I'll be throwing myself into the role."

Mike Steel

LOCAL NEWS

AUCKLAND UNIVERSITY OF TECHNOLOGY

SCHOOL OF ENGINEERING, COMPUTER AND MATHEMATICAL SCIENCES

Events

The department of Mathematical Sciences hosted the 2020 New Zealand Mathematical Society Colloquium on 1-2 December 2020. Over 140 participants attended this virtual event, and all sessions went smoothly. The colloquium was a remarkable success with many favorable comments from the participants.

Figure 1: *Some virtual morning tea is shared during the colloquium.*

The colloquium was held over these two days and was held online through Microsoft Teams. Although many speakers were unfamiliar with Teams before the event, after holding practice sessions, there were no real technical problems.

Each morning was a panel discussion, around 70 participants attended each. The theme of the first day was "COVID Modelling" and the second day was "Online Teaching and Learning in the Mathematical Sciences".

The Butcher-Kalman Lecture took place, this year's speaker was Melissa Tacy from the University of Auckland, with a talk titled "A Choose Your Own Adventure in Microlocal Analysis".

The NZMS Prizegiving was included, along with the NZMS AGM. Four special sessions were held on the afternoon of the second day:

- Education Group Contributed Talks;
- Education Group Workshop;
- NZ Mathematics in Wave Phenomena; and
- The 2020 AUT Mathematical Sciences Symposium.

A public screening of the film "Secrets of the Surface: The Mathematical Vision of Maryam Mirzakhani" was included in the colloquium.

About 50 people (AUT staff, MAnalytics current students and Alumni, industry partners) attended the 2020 Master of Analytics Mix and Mingle on 24 November 2020. The Dean of Faculty of Design and Creative Technologies Professor Guy Littlefair gave a keynote speech for the event. The event provided opportunities for people to build up collaborative network.

Figure 2: *Participants engaging in active discussions in the Mix and Mingle.*

Travel and Conference Participation

Professor Emeritus Jeff Hunter delivered an Invited talk in the Virtual Conference "International Conference on Applied Linear Algebra, Probability and Statistics" (ALAPS 2020) in honour of Prof C.R. Rao on his birth centenary year, sponsored by the Center of Advanced Research in Applied Mathematics and Statistics, MAHE, Manipal, India over the period 17-18 December 2020. His talk was on "The impact of Professor Rao's research used in solving problems in Applied Probability". In addition he chaired an online Group meeting where participants spoke on the influence of Professor Rao's research in their own research.

Dr Hyuck Chung traveled to Dunedin in November 2020 to continue his work with Dr Fabien Montiel and A/Prof Colin Fox at the University of Otago. They have been working on wave motions of elastic structures interacting with air or water.

Visitor

Professor Jeong-Hoon Kim (Yonsei University, Republic of Korea) visited the Department of Mathematical Sciences in July. Professor Kim is going to work with Professor Jiling Cao and Dr Wenjun Zhang on using mathematical models to evaluate financial derivatives.

Professor Graham Weir (Massey University) visited the department on Tuesday 13th and Wednesday 4th of October. Graham gave a guest lecture for the paper MATH706 titled 'Assessing earthquake risk to underground coalmines and underground roadways'.

Seminars

Associate Professor Sergiy Klymchuk took a sabbatical leave in second semester of 2020. He gave a seminar about his research and study leave activities titled 'A new type of questions for teaching and assessing critical thinking in mathematics'.

Professor Graham Weir gave a departmental seminar titled 'Modelling magnetic fields in magnetic composites' during his visit.

In February 2021, Shu Su successfully defended her PhD thesis. The title of Shu's PhD thesis "Mathematical analysis of the chaotic behavior in monetary policy games", supervised by Professor Jiling Cao and Dr Wenjun Zhang.

Wenjun Zhang

UNIVERSITY OF AUCKLAND

DEPARTMENT OF MATHEMATICS

The Mathematics Department was ranked 71st in the world in the 2021 QS rankings, an improvement by 10 places from last year's position of 81st. Of course such results should be taken with many grains of salt, but I think it is also credit to the excellent work being done in NZ Mathematics.

We continue to be in the early stages of the 3 year project to construct a new Recreation Centre. Demolition has ended and now the developers have been noisily working on piles and foundations.

Staffing

Josephina Ah Sam had a baby girl Sloane Lomialagi Iuliana Tamatoa in February. Marie Graff had a baby girl Andrea Rose Graff in April. Congratulations to Josephina and Marie.

We welcome Shamim Shadfar as our Group Services Admin (GSA), replacing Deana Lado.

Lauren Smith started as a lecturer in Applied Maths in 2021, and is working remotely from Sydney, Australia.

Tomasz Popiel is a temporary lecturer in Pure Maths for 2021. He is currently working remotely from Perth, Australia.

Alex Soudlenkova has taken over as Research Programme Manager for our cluster.

Congratulations to staff who were successful in the 2020 promotions round:

- Josephina Ah Sam Professional Teaching Fellow 3
- Jonny Stephenson Professional Teaching Fellow 3
- Nicolette Rattenbury Professional Teaching Fellow 4
- Sione Ma'u Senior Lecturer 1
- Igor' Kontorovich Senior Lecturer 6
- Graham Donovan Associate Professor
- Shayne Waldron Associate Professor

Claire Postlethwaite and Graham Donovan are on sabbatical this semester.

Stefan Ruschel, who is a post-doc Research Assistant on the Dodds Walls CORE, got a border exemption to return to NZ and arrived in February.

Awards and honours

Congratulations to Marston Conder, who was awarded the Euler Medal by the Institute of Combinatorics and its Applications. Marston's Citation reads: *Marston Conder has made many distinguished contributions to combinatorics over the last 40 years. He has a worldwide reputation for developing and applying techniques from combinatorial and computational group theory to answer questions and solve problems in a range of areas of mathematics with a particular focus on discrete objects (such as graphs, maps, polytopes, and Riemann surfaces) with maximum possible symmetry subject to given constraints. He has made many groundbreaking discoveries and answered many open questions in a wide range of topics, including graph symmetries, graph embeddings, regular and chiral maps, regular and chiral polytopes, as well as edge-partitions of graphs, higher-dimensional expander graphs, and binary Gray codes. Dr. Conder has published more than 170 papers, supervised 15 PhD students, and is a frequent invited speaker at international conferences. In addition, he is renowned for the way in which he freely shares his knowledge and the results of his research with others, and in particular, for his repositories of discrete objects of particular kinds, which he found using a combination of theory and computation. These are widely used, and have been helpful not only in answering new research questions but also in leading to new discoveries.*

Members of the Mathematics Department were recognised by the New Zealand Mathematical Society in the 2020 awards.

- The Early Career Research Award was awarded jointly to Geertrui Van de Voorde (Canterbury) and Gabriel Verret (Auckland).

- The Research Award went to Jeroen Schillewaert.
- The Kalman Prize for Best Paper went to Melissa Tacy
- The Gillian Thornley Award for outstanding contribution to the cause or profession of mathematics was jointly awarded to Liz Ackerley (Canterbury) and Rachel Passmore (Auckland).

Malia Puloka has been awarded the 2021 Goldstone Travelling Award.

Events

We held a very well-attended Memorial event for Vaughan Jones on Monday 7th December.

We celebrated the International Day of Mathematics (March 14) on Monday March 15th by holding a movie screening in collaboration with the UoA Maths Club of the documentary "Achieving the Unachievable" on mathematics and art.

Other news

Emeritus Professor John Butcher attended the NZMS Colloquium and ANZIAM conference on line. He gave an invited lecture (on line) at ICEMS 2020 (the International Conference on Education, Mathematics and Science) on 12 December 2020.

Sina Greenwood and Caroline Yoon are serving on an expert mathematics panel, chaired by Gaven Martin (Massey) to provide advice to support the refresh of the New Zealand Mathematics Curriculum.

Igor' Kontorovich was awarded an academic exchange fellowship by the Polish National Agency for visiting the Pedagogical University of Krakow in 2021. He also gave an online plenary lecture at the 9th Jerusalem Conference in Mathematics Education on the didactical potential of points of incoherence in mathematics.

Former staff member Joel Schiff has been granted the position of Astronomer with the international astronomical organisation Slooh and is currently tracking Near Earth Asteroids that may pose a danger to Earth using a large telescope remotely in the Canary Islands off the coast of Spain. He has also published a recent book "The Mathematical Universe: From Pythagoras to Planck", published by Springer-Praxis with a Foreword by Gerard't Hooft (Nobel Prize winner in Physics, 1999).

Steven Galbraith

UNIVERSITY OF WAIKATO

DEPARTMENT OF MATHEMATICS AND STATISTICS

Promotion

Nick Cavenagh was promoted to Associate Professor. He has developed a substantive body of research in discrete mathematics, particularly the areas of combinatorics and design theory. Other achievements include success in postgraduate supervision and a commitment to better learning outcomes for students, regardless of ability. He was a keynote speaker at the LOOPS 2019 Conference, Budapest University of Technology and Economics, Hungary, in 2019; and the Combinatorial Mathematics Society of Australasia Day (Workshop), online in 2020. He is also one of four invited minisymposium speakers for the session "Designs and Latin squares" at the 28th British Combinatorics Conference, Durham University, UK, in 2021.

Zubair Moughal completes the PhD

Zubair completed his PhD in January supervised by Woei Chet Lim. The title was "Generating spiky solutions of Einstein field equations with the Stephani transformation." A compacted version of the thesis has been published in the Journal Classical and Quantum Gravity. Zubair is now back in his homeland Pakistan, and has been interviewed for a permanent academic position there. An afternoon tea was held to celebrate Zubair's success. You can see his image at the annual department lunch picture below - he is on the far left.

Annual lunch

The annual lunch for 2020 was held in a lovely room of the "Bank" restaurant and bar in lower Victoria street. Thanks to Maria Admiraal, the Department Administrator, for arranging this, which was a very happy occasion. In the image below of the lunch, clockwise from the bottom right we have Maria, Raziyeh Zarrie, Chaitanya Joshi, Sean Oughton, Zubair Moughal, Han Gan, Daniel Delbourgo, Ian Hawthorn, Kevin Broughan, Nick Cavenagh, Stephen Joe, Jacob Heerikhuisen, Fahim Rahim, Tim Stokes, Julia Gaaston, and Hamish Gilmour.

People

Tim Stokes is on study leave, but taking it at the University of Waikato, given covid-19 as it rages around the world. Lyn Hunt and Raziyeh Zarrie and now part time. Daniel Delbourgo's masters cryptography paper has reached an all time high for student enrolments in any paper taught by the department at that level - 60! Kevin Broughan's "Bounded gaps between primes: the epic breakthroughs of the early 21st century" has been published by Cambridge.

Kevin Broughan

Annual lunch 2020 Department of Mathematics and Statistics

MASSEY UNIVERSITY

INSTITUTE OF FUNDAMENTAL SCIENCES

We were sad to have had to bid farewell to Luke Fullard from our group in February. Luke has taken up a position as a Data Analyst at Horizons Regional Council. Luke will be sorely missed by students and staff alike, but we wish him all the very best in his new role.

Richard Brown

SCHOOL OF NATURAL AND COMPUTATIONAL SCIENCES

The Auckland North Mathematics Olympiad Cluster (ANMOC) which began last year, was hosted for pre-tertiary able students on the Albany campus and coordinated by Professor Emeritus Graeme Wake and PhD student Mohsen Hashemi. This year it has shifted to Rangitoto College on the North Shore and is coordinated by a group of teachers led by Jamie Craik from that College. They have expanded its scope with two parallel programmes: a Junior one (Year 9 upwards) and a Senior programme (mostly years 12 and 13). The New Zealand Mathematics Olympiad Committee hosted its week-long national summer camp in Auckland in early January at which Graeme ran a workshop on geometrical symmetrisation. The training squad for the NZ International Mathematics Olympiad team (of six) in mid-2021 was selected during that week.

Winston Sweatman, Alona Ben-Tal and Neelum Bashir (PhD student) participated in the Australian and New Zealand Industrial and Applied Mathematics (ANZIAM) conference in the first week of February. The conference was held online using a virtual conference venue. Each attendee was assigned an "avatar" with which they could navigate in the virtual world using the arrows on their computer's keypad. The virtual world included a lobby, a plenary room, smaller rooms for the parallel sessions, another lobby where graphical abstracts were presented, a game room and a theatre room where pre-recorded lectures were shown in the early morning or later at night. The platform allowed for random interactions between attendees and was also linked with Zoom where talks were given. It was a very enjoyable experience and a superbly well-organized conference, much better than just Zoom but not as good as a real conference. Winston presented a talk entitled: "The symmetrical five-body problem and other fun stuff". Alona presented a talk entitled: "The logic behind neural control of breathing pattern". We were delighted to see Prof Mike Plank receiving the EO Tuck Medal. The award ceremony was quite emotional, and people were turning on their cameras as a sign of respect. If you wish to try a free demo of the virtual platform check out gather.town. The platform was customised and maintained by Virtual Chair.

In the latest administrative rearrangement, it is proposed that the Schools in which mathematics staff currently reside (the School of Fundamental Sciences in Manawatu and the School of Natural and Computational Sciences at Albany) be disestablished and replaced by two new schools, both having staff on both campuses, provisionally named the "School of Biological and Physical Sciences" and the "School of Mathematical and Computational Sciences". Mathematics staff would be part of the latter school.

Carlo Laing

VICTORIA UNIVERSITY OF WELLINGTON

SCHOOL OF MATHEMATICS AND STATISTICS

Camila Sehnem has finally joined us physically after arriving from Brazil and undergoing quarantine. Camila is funded by Iain Raeburn and Astrid an Huef's Marsden grant. We are also expecting Alejandro Frery to travel from Brazil to New Zealand in June to take up his position as Professor in Statistics and Data Science. That leaves Brendan Harding working remotely from Australia, that hot-bed of Covid-19.

We had a large Honours class last year, and many of them have enrolled in a Master. In particular, 6 Masters students and 2 PhD students obtained VUW scholarships to start this year.

Mark McGuiness will be plenary speaker at the ECMI2021 conference hosted by Bergische Universität

Wuppertal in Germany in April. It is the European Consortium for Mathematics in Industry, and will be a virtual conference, based on Zoom meetings. Mark will speak about detecting moisture in bauxite in real time on a conveyor belt, using microwaves.

Mark "went" to the ANZIAM annual meeting at the beginning of February, hosted by Monash University, again virtual but based on a very engaging environment called GatherTown. They walked avatars around a set of conference rooms, and easily met with and chatted with other participants if our avatars got close to each other. Zoom meetings were also integrated into this environment. Such fun! Many talks were also recorded to 15-minute video and available to view at times that might suit attendees from different time zones.

Mark was heading up a group of industrial applied mathematicians who were preparing a Bid on behalf of ANZIAM to host ICIAM2021 in Auckland. They have just withdrawn their bid, based on local concerns about risk, carbon footprint (of flights, as the NZ International Conference Centre in Auckland is carbon neutral), the amount of work such a large conference would require, and the current uncertainty about university funding and job security.

Rod Downey gave a talk "Mathematics and Scottish Country Dancing" at the University of the Third Age (U3a) which "aims to encourage an active retirement for men and women by providing for their cultural, social, physical and intellectual interests". Rod described his talk as "Riveting stuff, lots of people in the audience (but it did have free tea and bikkies) and they all rushed off at the end to get on the busses before 3.00 for the Gold Card." The photo of Rod at the talk, in kilt and maths T-shirt, was supplied by Rod's wife Kristin.

Astrid an Huef

UNIVERSITY OF CANTERBURY

SCHOOL OF MATHEMATICS AND STATISTICS

A number of congratulations are in order for major achievements of staff in the School. *Brendan Creutz*, *Daniel Gerhard*, *Jeanette McLeod*, *Blair Robertson* and *Phillip Wilson* were promoted to Senior Lecturer Above the Bar.

Charles Semple and *Mike Steel* were successful in the recent Marsden round with their project entitled Diversity indices and extinction cascades: New mathematical techniques to capture the disappearing 'Tree of Life'. The project is in collaboration with associate investigators Arne Mooers from Simon Fraser University, Canada, and Tanja Stadler from ETH Zürich, Switzerland.

Congratulations to *Geertrui Van De Voorde* who has been awarded an Early Career Research award of the NZMS. This award recognises excellent research carried out by early-career New Zealand-based mathematicians and is based on three published research outputs. Geertrui has made profound contributions to finite geometry, particularly creative and foundational analyses of linear sets and their applications to coding theory.

Congratulations to *Liz Ackerley* who has been awarded the Gillian Thornley award. This award is for an outstanding contribution to the cause or profession of mathematics, and was made for the first time last year. The award recognizes Liz's 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.

Douglas Bridges, *Jeanette McLeod*, and *Phil Wilson* became NZMS fellows. 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.

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.

Jeanette and Phil have made important contributions to mathematics in NZ through the Maths Craft outreach initiative that they both founded 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 while Phil made strong contributions through his research in fluid dynamics and mathematical biology.

At the end of last year *Leigh Davidson* received a Camelia Award form TEU to mark last year's Women's Suffrage anniversary.

Congratulations to Canterbury Distinguished Professor Roy Kerr on being awarded the 2020 Oskar Klein Medal by the Royal Swedish Academy of Sciences.

At the end of November last year the School farewelled *Mark Hooper* who had been in the School for less than a year. His infectious enthusiasm, finesse as an educator, and passion for exploring new boundaries of pedagogy will serve him well in his new role as Head of Mathematics at St Peter's School in Cambridge.

At the beginning of the year *Louis Warren*, *Robert Culling* and *Weichen (Speedy) Jiang* joined the school

on one-year contracts, Louis as Lecturer (Teaching and Admin only) and Robert and Speedy as Senior Tutors. They will be helping us to develop online course content and to coordinate and deliver the large footprint of online courses that we have this year in data science, engineering mathematics, mathematics and statistics, as well as lecturing and tutoring. All three are well known in the School.

Louis is a graduate of the University of Canterbury and completed his PhD in constructive logic in 2019 here. He previously lectured part time in 2020. His research interests are in minimal logic and automated proof verification.

Robert completed his BSc at the University of Canterbury in 2014 and moved to Canberra in 2015 to begin doctoral studies in arithmetic geometry under the supervision of James Borger at the Australian National University. Robert competed his PhD there in 2019 and stayed on at ANU for six months as a post-doc. Since returning to Christchurch he had been on a fixed term contract to tutor and lecture on 100 level mathematics courses, and help develop course materials, in particular quiz questions using STACK, for online courses. When not thinking about mathematics, Robert enjoys bouldering, listening to music, and hiking in the mountains. He also tends to enjoy these things when thinking about mathematics.

Speedy came to the School in July 2018 to study for a Master of Applied Data Science, which he completed at the end of 2019. During this time he became a tutor in the introductory statistics course STAT101 Statistics 1 and DATA423 Data Science in Industry. In his new role he continues to tutor in these two courses, but his main role is to liaise with STAT101-distance students, maintain the course web page, organize and conduct Zoom tutorials, and generally help with students' queries and ease the difficulties arising due to the distance and time difference. Speedy is a huge Lego fan, owns some collections of Mindstorms and Technic series, and had been leading Lego after-school activities for about five years. He is also enthusiastic about hiking, star gazing and photography, which was part of the motivation to move here.

Charles Semple and *Mike Steel* organised the 25th Annual New Zealand Phylogenomics Meeting, Akaroa 2021, a conference on the mathematics of evolution and phylogenetics, held in the second week of February in the seaside village of Akaroa on Banks Peninsula. Conferences in this series of annual summer meetings bring together mathematicians and biologists. The meeting usually attracts around 20 overseas participants, but this year only 30 NZ-based participants could attend. It was held at Mt Vernon Lodge, which is where next year's NZMRI summer workshop will take place (organised by Brendan Creutz and Felipe Voloch).

With the ongoing travel restrictions the international Erskine programme of the university is still on hold, but we were able to nominate NZ based fellows. So in March the School welcomed Peter Smith from Victoria University of Wellington as an Erskine Fellow for a three months visit. Peter is well known in the School as he was previously at the University of Canterbury in the Department of Electrical Engineering and teaching statistics in the School. Peter's research speciality is the study of mobile wireless systems underpinned by a mathematical approach to engineering design and analysis that makes extensive use of statistics and probability. His general research area is the development of state of the art transmitter and receiver architectures for future mobile radio systems and the fundamental analysis of wireless links involving probabilistic system analysis, statistical modelling, distribution theory and information theory. Peter is hosted by *Marco Reale* and is teaching into STAT211 Random Processes.

Robert Culling (left) and Speedy Jiang

Participants at Akaroa 2021

Günter Steinke

UNIVERSITY OF OTAGO

DEPARTMENT OF MATHEMATICS AND STATISTICS

Sarah Wakes

Sarah Wakes is the new HoD Mathematics and Statistics. English-born, Sarah completed a PhD in applied mathematics in the University of Nottingham's School of Engineering. Her research has a focus on computational fluid dynamics for physical world applications, which range from the safety of personnel on offshore oil super-structures to modelling sediment movement on foredunes at St Kilda. In her own words: "All my professional and personal interests seem to come together in the physical world, to understand what's happening, and how to make it better." Sarah joined the Department of Mathematics and Statistics two years ago, after her arrival at Otago in 2002 to teach in the Department of Design Studies, followed by time in the Department of Applied Sciences and the Centre for Materials Science and Technology. Now she has taken over the role of HoD from Robert Aldred, who retired this April, see below. Congratulations, Sarah, and many thanks (and good luck!) for leading the Department through challenging times.

We bid farewell to *Robert "Tank" Aldred*, who retired this April. Tank grew up in the Australian bush and moved to the University of Melbourne to complete his formal education. After short term positions first at Otago and then Southern Illinois University, he came back to Otago in 1989. Here, he has held a position ever since, rising through the ranks to a very well deserved personal chair in 2010. In 2016, he took up the position of the Department's HoD, which he held until the end of 2020. Tank's work covers many areas including latin squares, combinatorial designs, association schemes and permutation patterns, but his main interest has always been with graphs, in particular, in determining bounds on the existence of special structures such as perfect matchings, 2-factors and cycles. One of many examples of Tanks groundbreaking results is his work on perfect matchings with Michael Plummer (Vanderbilt University), which established proximity thresholds for matching extensions that were unanticipated by others working in this field. Tank, we are very grateful to you for everything you have done for the Department. All the best to you and your wife Karen for a happy retirement!

Robert Aldred

The Department's Gravity research group has received the Outstanding Research Group Award from the Division of Sciences. The group, which consists of *Jörg Frauendiener, Florian Beyer, Jörg Hennig and Chris Stephens* was presented with this "for its outstanding

contributions to the understanding and interpretation of solutions of Einstein's equations of General Relativity. Their work has shed important new light on the asymptotic structure of spacetimes, the structure of the early universe evolving from the Big Bang, and the properties of multi-black hole spacetimes."

The NZMS Aitken Prize was awarded to *Pedro Barboza Rossetto*, who is a PhD student of Jörg Frauendiener's. The Society offers the prize for the best contributed talk by a student at the annual New Zealand Mathematics Colloquium. Pedro received the prize for his talk "Chaos in plane fronted gravitational waves". Congratulations, Pedro!

Jörg Hennig

PhD SUCCESS

Zubair Moughal (University of Waikato)

Title: Generating spiky solutions of Einstein field equations with the Stephani transformation

Supervisor: Dr Woei Chet Lim

Abstract: The Geroch/Stephani transformation is a solution-generating transformation, and may generate spiky solutions. The spikes in solutions generated so far are either early-time permanent spikes or transient spikes. We want to generate a solution with a late-time permanent spike. We achieve this by applying the Stephani transformation with the rotational Killing vector field of the locally rotationally symmetric Jacobs solution. The late-time permanent spike occurs along the cylindrical axis. The generated solution also features a rich variety of transient structures. We introduce a new technique to analyse these structures. Our findings lead us to discover a transient behaviour, which we call the overshoot transition.

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Shu Su (Auckland University of Technology)

Title: Pricing volatility derivatives under Lévy processes

Supervisors: Jiling Cao and Wenjun Zhang

Abstract: In this thesis, we study the pricing for the volatility derivatives, including VIX options, VIX futures, VXX options and S&P 500 variance futures, under Lévy processes with stochastic volatility. In particular, we investigate the role of different types of jump structures, such as finite-activity jump, infinite-activity jump and double jump structures, as well as the role of variance processes with time-varying mean in the valuation of volatility derivatives. In our models, we assume that the long-term mean of the variance process follows an Ornstein–Uhlenbeck process and specify the infinity-activity jump component of the main process in four cases: the variance gamma process (VG), the normal inverse Gaussian process (NIG), the tempered stable process (TS) and the generalized tempered stable process (GTS). Then, we apply the combined estimation approach of an unscented Kalman filter (UKF) and maximum log-likelihood estimation (MLE) to our models and make an extensive comparison analysis on the performance among the different models.

Our empirical studies reveal three important results. First, the models with infiniteactivity jumps are superior to the models with finite-activity jumps, particularly in pricing VIX options and VXX options. Thus, the infinite-activity jumps cannot be ignored in volatility derivative pricing. Second, both the infinite-activity jump and diffusion components play important roles in modelling the dynamics of the underlying asset returns for the volatility derivatives. Third, the mean of the variance process for the S&P 500 index returns varies stochastically toward to its long-term mean.

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Elle Musoke (University of Auckland)

Title: Geometry of Manifolds in the Four-Dimensional Olsen model

Supervisors: Hinke Osinga (main supervisor), Bernd Krauskopf (co-supervisor)

Abstract: Slow-fast dynamical systems are systems in which some variables change faster than others. From chemical reactions to electric circuits, examples of slow-fast systems are found in a wide variety of disciplines. By reason of their ubiquity, phenomena that arise from the multiple-time-scale nature of slow-fast dynamical systems are of great interest. In particular, we study mixed-mode oscillations (MMOs), periodic orbits that have segments of low amplitude oscillations and segments of high amplitude oscillations. Mechanisms for generating MMOs in four-dimensional slow-fast systems are largely unexplored. We investigate a mechanism for MMOs in the four-dimensional, slow-fast Olsen model for peroxidase-oxidase reaction; we consider the parameter regime where one of its four variables evolves much slower than the other three. Fenichel theory guarantees the existence of so-called slow manifolds that lie close to and have the same dimension as actual invariant manifolds that only exist in the singular limit when the slow flow is frozen. The Olsen model features two one-dimensional saddle slow manifolds of different type: one saddle slow manifold has three-dimensional stable and two-dimensional unstable manifolds and the other has two-dimensional stable and three-dimensional unstable manifolds. Numerical continuation methods and appropriately defined boundary-value problems are used to compute chosen two-dimensional submanifolds of the three-dimensional stable and unstable manifolds. We then use a Lin's method approach to compute the

two-dimensional intersection surface of the three-dimensional stable and unstable manifolds, which is comprised of heteroclinic connections between the saddle slow manifolds. This surface is a saddle object that is repelling in forward and backward time. Nevertheless, it is a crucial ingredient for generating MMOs in the Olsen model: the novelty of the mechanism lies in that the MMO periodic orbit tracks the surface of heteroclinic connections between the two saddle slow manifolds. Furthermore, this process produces an intermediate time scale, induced by the flow on the heteroclinic manifold. We find that the MMO belongs to a two-parameter family of MMO periodic orbits and consider an additional nineteen MMO periodic orbits that co-exist for the original parameter values and are all unstable. Similarly to how one-dimensional trajectories may organise MMOs in a three-dimensional system, we show how the two-dimensional surface of connections controls the number of small-amplitude oscillations (SAOs) an MMO makes, in spite of it not being a separatrix in four-dimensional space. We intersect the MMOs and the surface with a three-dimensional section. The intersection curves and points reveal the presence of rotational sectors organising the small-amplitude oscillations of the MMO periodic orbits. We demonstrate how a projection of the intersection of the surface with a three-dimensional section onto two-dimensional space can be used to predict the number of SAOs for all co-existing MMOs.

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Emma Greenbank (Victoria University of Wellington)

Title: Modelling Surtseyan Ejecta

Supervisor: Mark McGuinness

Abstract: Eruptions through crater lakes or shallow sea water, known as Subaqueous or Surtseyan eruptions, are some of the most dangerous eruptions in the world. These eruptions can cause tsunamis, lahars and base surges, but the phenomenon of interest to this research is that of the Surtseyan ejecta. Surtseyan ejecta are balls of highly viscous magma containing entrained material. They occur when a slurry of previously erupted material and water washes back into the volcanic vent. This slurry is incorporated into the magma and ejected from the volcano inside a ball of lava. The large variation in temperature between the slurry and the lava causes the water in the slurry to vaporise. This results in a pressure build-up which is released by vapour either escaping through the pores of the lava or the ejectum exploding. The volcanological question of interest is under what conditions these ejecta rupture.

During this thesis the aim is to improve on the existing highly simplified model of partial differential equations that describe the transient changes in temperature and pressure in Surtseyan ejecta. This is achieved by returning to the basics and developing a model that is more soundly based on the physics and mathematics of Surtseyan ejecta behaviour. This model is developed through the systemic reduction of the coupled nonlinear partial differential equations that arise from the mass, momentum and energy conservation equations to form a fully coupled model for the behaviour of Surtseyan ejecta.

The fully coupled model has been solved numerically as well as reduced further to produce analytical solutions for temperature and pressure. The numerical solutions show a boundary layer of rapidly varying temperatures and pressures around the steam generation boundary. This allows for a boundary layer analysis to be used in both the magma and the inclusion to estimate the temperature profile at early times. The numerical solution also showed a rapid increase in pressure at the flash front that allowed for a quasi steady state approximation in pressure to be used to form a reduced model that could be analytically solved. This produced an updated criterion for rupture and a criterion for the lower limit of permeability. The analytical and numerical results were then compared to the data from existing intact ejecta for verification.

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GENERAL NOTICES

Marston Conder awarded 2020 Euler medal

Distinguished Professor Marston Conder, Mathematics, has been awarded the 2020 Euler medal by the Institute of Combinatorics and its Applications. Euler Medals recognize distinguished lifetime career contributions to combinatorial research by Fellows of the ICA, including those who remain active in research.

Marston's citation reads as follows:

"Marston Conder has made many distinguished contributions to combinatorics over the last 40 years. He has a world-wide reputation for developing and applying techniques from combinatorial and computational group theory to answer questions and solve problems in a range of areas of mathematics with a particular focus on discrete objects (such as graphs, maps, polytopes, and Riemann surfaces) with maximum possible symmetry subject to given constraints. He has made many ground-breaking discoveries and answered many open questions in a wide range of topics, including graph symmetries, graph embeddings, regular and chiral maps, regular and chiral polytopes, as well as edge-partitions of graphs, higher-dimensional expander graphs, and binary Gray codes.

Dr. Conder has published more than 170 papers, supervised 15 PhD students, and is a frequent invited speaker at international conferences. In addition, he is renowned for the way in which he freely shares his knowledge and the results of his research with others, and in particular, for his repositories of discrete objects of particular kinds, which he found using a combination of theory and computation. These are widely used, and have been helpful not only in answering new research questions but also in leading to new discoveries."

David Bryant

The 13th Delta Conference

On behalf of the organising committee, we are delighted to share the first announcement of the 13th Southern Hemisphere Delta Conference on the Teaching and Learning of Undergraduate Mathematics and Statistics to be held on 22–25 November 2021 at the University of Auckland, New Zealand. For the first time, the conference presentations will be made online via video conferencing. Delta attracts an international audience of academics interested in mathematics and statistics education, including disciplinary specialists, education theorists, and tertiary education practitioners across the mathematical sciences and engineering. Traditionally, the conference focuses not only on the dissemination of practical initiatives but also on research outputs, which are published as double-blind peer-reviewed articles in the special issue of the International Journal of Mathematical Education in Science and Technology (submission deadline is 6 April https://think.taylorandfrancis.com/special_issues/conference-teaching-learning-undergraduate-mathematics-statistics/?utm_source=TFO&utm_medium=cms&utm_campaign=JPG15743 guest editor: Tanya Evans) and as full double-blind peer-reviewed papers in the conference proceedings (submission deadline is 13 August; editors: Stephanie Budgett and Rosalind Cameron).

Registrations will open on 18 February 2021. Early-bird conference registration fee is NZ $120 before 30 September 2021, while the standard conference registration fee is NZ $150 after 30 September 2021.

For further information about the conference, see our website: https://www.herengadelta.org/.

Local Organising Committee: Stephanie Budgett, Rosalind Cameron, Tanya Evans, Phil Kane, Rachel Passmore, Cami Sawyer, Kerri Spooner

Convenor: Phil Kane

Phil Wilson

La Matematica journal

The Association for Women in Mathematics announces La Matematica.

The Association for Women in Mathematics has recently announced its first research journal, La Matematica, published by Springer. It seeks to publish a variety of article types in all fields of mathematics: pure, applied, and computational. They include work on a wide spectrum of topics, ranging from mathematics education and the history of mathematics to mathematically-grounded work in data science, computer science, and statistics. Occasionally they will also publish special thematic issues. They aim for:

- publication of high quality research from a broad range of the mathematical sciences;
- doubly-anonymous review process;
- constructive reviews;
- quick reviewer turn-around time.

Please consider submitting your next high-quality paper to La Matematica: https://www.springer.com/journal/44007

Astrid an Huef

MATHS CRAFT new zealand

explore, educate, create

Sunday 23 May 2021

The Christchurch Maths Craft Day: celebrating connections between maths and craft.

- Fold an origami octahedron
- Knit a mathematical knot
- Crochet a Möbius strip
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NZMS

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NZMS NOTICES

NZMS Colloquium 2021

The NZMS Colloquium 2021 will be held at the University of Canterbury from 7–9 December 2021, with a welcome function on 6 December. An education afternoon is also planned. The convener is Prof Charles Semple (charles.semple@canterbury.ac.nz).

Calls for nominations for NZMS Awards and Fellowships

The NZMS recognises excellence in mathematical research and service to the NZ mathematical community through awards and an accreditation (fellowship) scheme. The Council asks that you all actively encourage eligible colleagues to apply for these awards and/or offer to nominate them, especially women, those of Māori ethnicity, or other members of the NZ mathematical community who are under-represented among past awardees and fellows.

Below are calls for nominations for the specific awards and for NZMS fellowships, along with their deadlines. Further details on all the awards, including past recipients, eligibility, and how to nominate someone (or self-nominate), can be found at: http://nzmathsoc.org.nz/?awards. Fellowship information and application forms can be found at: http://nzmathsoc.org.nz/?accreditation.

2021 Gillian Thornley Award for outstanding contribution to the cause or profession of mathematics

This annual award was established in 2020 to recognize outstanding contributions to the cause or profession of mathematics in New Zealand. For the purposes of this award, "contribution to the cause or profession or mathematics" could include (but is not limited to) contributions to teaching and education, research leadership, outreach, engagement with government bodies, diversity, service to professional societies, mentoring, and communication of mathematics to a general audience.

Eligibility. Nominees need not be members of the NZMS but the award would normally be given for work that took place in New Zealand and contributed to NZ mathematics.

Nominations should be sent by email to the NZMS President, Prof David Bryant (david.bryant@otago.ac.nz) by 31 August 2021. Submissions should state clearly that they are for the Gillian Thornley Award.

2021 NZMS Early Career Research Award

This award was instituted in 2006 to foster mathematical research in New Zealand and to recognise excellent research carried out by early-career New Zealand mathematicians. Candidates will be judged on their best three published research outputs and a brief CV. Research outputs could include publications in books, journals, other peer-reviewed venues, or other types of high quality mathematical research.

Eligibility. Candidates may contact the NZMS President in confidence for clarification of how the following eligibility criteria apply to their particular circumstances: candidates should be within ten years of confirmation of PhD, but an appropriate adjustment to this time period can be made to take into account career breaks or periods of reduced workload; and, candidates must have worked or studied in NZ for at least 30 months in the three calendar years immediately prior to the award year, with an appropriate adjustment for career breaks (candidates who leave New Zealand during, or prior to, the award year but satisfy all other conditions remain eligible); and, candidates must be current members of the NZMS; and no person can receive the award more than once.

All nominations and applications should be sent by email to the NZMS President, Prof David Bryant (david.bryant@otago.ac.nz) by 31 August 2021. Submissions should state clearly that they are for the NZMS Early Career Award, and should follow the guidelines at http://nzmathsoc.org.nz/?awards.

2021 NZMS Research Award

This annual Award was instituted in 1990 to foster mathematical research in New Zealand and to recognise excellence in research carried out by mathematicians in New Zealand. This Award is based on mathematical research

published in the last five calendar years (2016–2020). This could include research published in books, journals, other peer-reviewed venues, or other types of high quality mathematical research. This assessment period may be adjusted to take into account an interrupted career pattern. Candidates may contact the NZMS President in confidence for clarification of how the adjustment of time period applies to the their particular circumstances.

Eligibility. To be eligible for the Award, a candidate must be a current member of the NZMS and must have been a resident of New Zealand for the last three years.

Nominations and applications should be sent by email to the NZMS President, Prof David Bryant (david.bryant@otago.ac.nz) by 31 August 2021. Submissions should state clearly that they are for the NZMS Research Award, and should follow the guidelines at http://nzmathsoc.org.nz/?awards.

2021 Kalman Prize for Best Paper

The Kalman Prize for Best Paper was instituted in 2016 to recognise excellence in research carried out by New Zealand mathematicians. The Prize will normally be awarded annually for an outstanding and innovative piece of research in the mathematical sciences published by a member or members of the NZMS. The Prize is for a single publication of original research, which may be an article, monograph or book, having appeared within the last 5 calendar years: 2016–2020. The value of the Prize is $5000. The Prize is generously funded by the Margaret and John Kalman Charitable Trust, and recognises the significant contributions to mathematics in New Zealand made by Professor John Kalman.

Eligibility. A publication may be nominated for the Prize by any member of the NZMS who is not an author of that publication. To be eligible, the nominated publication must have at least one author who: (i) is a current member of the NZMS, and was a member in the calendar year of publication of the nominated work; and (ii) is a resident of New Zealand, and was a resident of New Zealand at the time when the research was carried out.

Nominations should be sent by email to the NZMS President, Prof David Bryant (david.bryant@otago.ac.nz) by 31 August 2021. Submissions should state clearly that they are for the Kalman Prize for Best Paper, and should follow the guidelines at http://nzmathsoc.org.nz/?awards.

Fellowships of the NZMS

The New Zealand Mathematical Society, like many other societies, has an accreditation scheme. In particular, members may be recognised with the award of Fellowship of the NZMS. The NZMS encourages members to consider applying, and additionally, encourages members to nominate colleagues who meet the criteria. The complete criteria follow, all three of which are to be satisfied.

- Shall normally have been a Member of the NZMS for a period in excess of three years.
- Shall have had the qualifications of an Accredited Member for a period in excess of three years (i.e. have completed a postgraduate degree in mathematics at a recognised university or other tertiary institution, or shall have equivalent qualifications, and shall have been employed for the preceding three years in a position requiring the development, application or teaching of mathematics.)
- Shall have satisfied criteria (3.1 or 3.2 or 3.3 or 3.4) and 3.5:
  - 3.1. have made a substantial and sustained contribution to the mathematical sciences;
  - 3.2. have made a substantial and sustained contribution to the profession of mathematical scientist;
  - 3.3. have made a substantial and sustained contribution to the teaching and learning of the mathematical sciences;
  - 3.4. have made a substantial and sustained contribution to the application of the mathematical sciences;
  - 3.5. have made a substantial and sustained contribution to the New Zealand mathematics community.

Members' applications are encouraged before 1 June 2021.

Next deadline for applications for Financial Assistance — 15 May

The NZ Mathematical Society has quarterly deadlines for financial assistance applications. Applications must be made well in advance (at least one month before the funded activity, but the earlier the better) and retrospective applications will not be considered. The remaining deadlines for applications for 2021 are: 15 May, 15 August, and 15 November. You should hear back from the Council within a month of the deadline. The types of grants are as follows.

NZMS Student Travel Grants

The NZMS invites applications from students for financial support for the presentation of research at conferences, attending workshops, and developing new collaborations. Typical grants for travel within NZ and Australia are in the range $200–$600. For travel further overseas, larger grants may be considered. To be eligible, a student must be based at an institution in New Zealand and be active within the New Zealand mathematical community. NZMS Student Travel Grants can contribute to costs including: flights, conference registration, accommodation, and travel-related costs associated with family responsibilities.

NZMS Student Travel Grants are generously supported by an annual grant from the Margaret and John Kalman Charitable Trust .

NZMS Financial Assistance

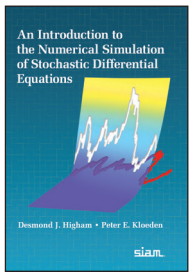
The NZMS invites applications for financial assistance with the costs of mathematical research-related activity. Any research-related activity will be considered. For example: hosting mathematical visitors; organising conferences, workshops, or outreach activities; and conference attendance, including costs associated with family responsibilities.

Further information and application details can be found on the NZMS website: http://nzmathsoc.org.nz/?assistance.

SIAM Books

An Introduction to the Numerical Simulation of Stochastic Differential Equations

Desmond J. Higham and Peter E. Kloeden

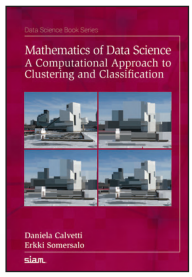


This book provides a lively and accessible introduction to the numerical solution of stochastic differential equations with the aim of making this subject available to the widest possible readership. It presents an outline of the underlying convergence and stability theory while avoiding technical details. Key ideas are illustrated with numerous computational examples and computer code is listed at the end of each chapter. The authors include 150 exercises, with solutions available online, and 40 programming tasks. Several modern topics, including Itô versus Stratonovich calculus, multilevel Monte Carlo, and tau leaping, are discussed.

2021 • xvi + 277 pages • Hardcover • 978-1-611976-42-7
List $79.00 • SIAM Member $55.30 • OT169

Mathematics of Data Science
A Computational Approach to Clustering and Classification

Daniela Calvetti and Erkki Somersalo

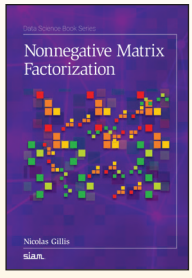


This self-contained textbook provides a solid mathematical basis for understanding popular data science algorithms for clustering and classification and shows that an in-depth understanding of the mathematics powering these algorithms gives insight into the underlying data. It presents a step-by-step derivation of these algorithms, outlining their implementation from scratch in a computationally sound way. The book proposes different ways of visualizing high-dimensional data to unveil hidden internal structures and includes graphical explanations and computed examples using publicly available data sets.

2020 • x + 189 pages • Softcover • 978-1-611976-36-6
List $64.00 • SIAM Member $44.80 • DI01

Nonnegative Matrix Factorization

Nicolas Gillis

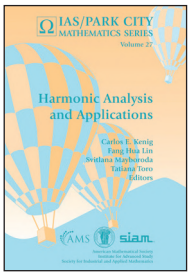


Nonnegative matrix factorization (NMF) in its modern form has become a standard tool in the analysis of high-dimensional data sets. This book provides a comprehensive and up-to-date account of the most important aspects of the NMF problem and is the first to detail its theoretical aspects, including geometric interpretation, nonnegative rank, complexity, and uniqueness. It explains why understanding these theoretical insights is key to using this computational tool effectively and meaningfully. The book is accessible to a wide audience and is ideal for anyone interested in the workings of NMF. It discusses some new results on the nonnegative rank and the identifiability of NMF and makes available MATLAB codes for readers to run the numerical examples presented in the book.

2020 • xxvi + 350 pages • Softcover • 978-1-611976-40-3
List $87.00 • SIAM Member $60.90 • DI02

Harmonic Analysis and Applications

Carlos E. Kenig, Fang Hua Lin, Svitlana Mayboroda, and Tatiana Toro

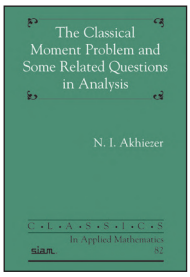


The origins of harmonic analysis come from an ingenious idea of Fourier: that any reasonable function can be represented as an infinite linear combination of sines and cosines. Today's harmonic analysis incorporates elements of geometric measure theory, number theory, and probability, and has countless applications. This volume provides a fresh, concise, and high-level introduction to recent developments in the field, often with new arguments not found elsewhere. It is based on lectures presented at the Park City Math Institute - Institute for Advanced Study summer school on harmonic analysis.

2020 • 345 pages • Hardcover • 978-1-470461-27-0
List $110.00 • SIAM Member $77.00 • AS04

The Classical Moment Problem and Some Related Questions in Analysis

N. I. Akhiezer

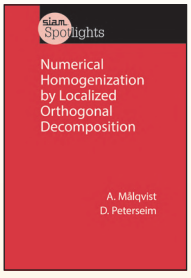


The mathematical theory for many application areas depends on a deep understanding of the theory of moments. This self-contained book presents a unified treatment of the development of the classical moment problem, including important connections between the moment problem and many branches of analysis. Readers will find a unified exposition of important classical results as well as a strong foundation for many areas in modern applied mathematics.

2020 • xiv + 253 pages • Softcover • 978-1-611976-38-0
List $69.00 • SIAM Member $48.30 • CL82

Numerical Homogenization by Localized Orthogonal Decomposition

Axel Målqvist and Daniel Peterseim



This book presents the first survey of the Localized Orthogonal Decomposition (LOD) method, a pioneering approach for the numerical homogenization of partial differential equations with multiscale data beyond periodicity and scale separation. The authors provide a careful error analysis, including previously unpublished results, and a complete implementation of the method in MATLAB. They also reveal how the LOD method relates to classical homogenization and domain decomposition. Illustrated with numerical experiments that demonstrate the significance of the method, the book is enhanced by a survey of applications including eigenvalue problems and evolution problems.

2020 • xii + 108 pages • Softcover • 978-1-611976-44-1
List $44.00 • SIAM Member $30.80 • SL05