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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 Miguel A Moyers González and Phillip L Wilson. 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 phillip.wilson@canterbury.ac.nz. LaTeX templates are available upon request from the editors.

The official address of the Society is:

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

However, correspondence should normally be sent to the Secretary:

Emily Harvey
M.E
PO Box 331297
Takapuna 0740
Auckland
New Zealand
emily.harveyNZ@gmail.com

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NZMS homepage: nzmathsoc.org.nz (Webmaster: bbaeumer@maths.otago.ac.nz)

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

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EDITORIAL

Welcome to the final Newsletter issue of 2017, which features a broad range of articles and opinion pieces, as well as reports and notices about upcoming events.

Of particular interest is Astrid an Huef's final President's Column of her Presidency of the NZMS, on page 4. We are sure we speak for everyone reading this Newsletter when we thank Astrid for her wonderful service to the Society.

Astrid's column is her President's Report for 2017, which also includes a report of prizes, awards, and fellowships bestowed at the NZMS Colloquium in Auckland, December 2017. We have illustrated this part of the report with some photographs from the event.

It is a real pleasure to put together issues like this one, full as it is with ideas and reports from a busy Society. We have enjoyed our two years as co-Editors of the Newsletter, and will edit the three issues to appear in 2018. Please get in touch with us if you are interested in taking over the Editorship from the first issue of 2019. Building on the sterling work of our predecessors, we can report that the typesetting is mostly painless, and that correspondents and contributors are usually only too keen to supply their words.

Finally, what is your opinion of the Newsletter? As Editors, we worry that it may seem like a passive document, to be grazed on lightly, barely digested. The popcorn of the printed word. We would rather it were something substantial, to be chewed over, ruminated, and which either nourishes or prompts dyspeptic emails to authors and editors. Please get in touch to let us know, and heed the call from this issue's authors to request preprints, to email with suggestions, and to get involved in calls to arms.

We look forward to hearing from you.

Miguel Moyers and Phil Wilson

PRESIDENT'S COLUMN

The column for this issue will be the President's Report for 2017.

President's Report, 2017
New Zealand Mathematical Society

This year's New Zealand Mathematics Colloquium was at the University of Auckland. I thank the organisers, especially the co-convenors Tom ter Elst and Hinke Osinga, for all the work involved with this.

Membership

The current membership is 260, up from last year's 253. We have 63 student members. We welcome several new members this year. Please encourage new colleagues and students to join our Society. The first year of membership is free.

Lecture Tours

The 2017 Maclaurin Lecturer was Ken Ono from Emory University. His public lectures "Gems of Ramanujan and their Lasting Impact on Mathematics" and colloquium talk "Jensen polynomials for Riemann's Xi-function and suitable arithmetic sequences" were very well received. I am grateful to Shaun Cooper for coordinating Ken's tour. Felipe Voloch's report on the tour is on page 28.

Unfortunately, Ken was the last Maclaurin Lecturer. The Maclaurin Lectureship has been a reciprocal exchange between the New Zealand and the American Mathematical Societies, and the agreement expires at the end of 2017. While the AMS viewed the exchange as a success, they did not want to extend the agreement. Instead, the AMS expressed interest in a second joint AMS–NZMS conference and we are currently in correspondence with them about that.

We also have the Forder and Aitken Lecture Tours which are reciprocal two-yearly exchanges between the London Mathematical Society and the NZMS. The current NZMS–LMS agreement is for one more Forder Lecture Tour in 2018 and one more Aitken Lecture Tour in 2019. Valerie Isham, from University College London, is the 2018 Forder Lecturer; she will tour NZ universities in April. I am grateful to Mick Roberts for coordinating Valerie's tour.

The Forder Lectureship is of great value to the New Zealand mathematics community and has historical significance. All the past Forder Lecturers have been research mathematicians of international acclaim who have spoken effectively at the research level, as well as at the more popular level of a public lecture. The feedback from mathematical departments has been very positive: there is general agreement that the Forder Tours are very beneficial to our community. We have written to the LMS expressing our wish to continue both Lectureships beyond 2019.

More Funding from the Kalman Trust for Students

The Margaret and John Kalman Charitable Trust has committed to support our Student Travel Grant Scheme by $5000 per annum in 2017–2019. This support will be reviewed in 2019, and will hopefully be continued. I thank Vivien Kirk for negotiating this support with the Trust.

December 2016 to August 2017: Student Travel Grants and Other Funding

We awarded student travel grants to Jurij Volcic, Cris Hasan, Valerie Chopovda (Gloria Olive Award 2016), Anggha Nugraha, James Hannam, John Moala (Gloria Olive Award 2017), Jose Mujica, Barak Shani, S. Vahid Amirinezhad, Vee-Liem Saw, Yan Bo Ti.

We supported several conferences: MINZ 2017, NZMASP 2017, ANZAMP 2018 and the Mirzakhani Hui: Women in Mathematical Sciences Conference (Lower North Island). We also put aside funding for 5 students from outside the Auckland area to attend the Conformal and Symplectic Geometry Conference.

We supported the national Maths Craft Festival. While the NZMS does not fund postdocs to travel in general, this year we contributed towards additional costs arising from a postdoc's family responsibilities during their travel.

NZMS Awards

I thank the members of the Judging Panels for their work in judging the applications and nominations we received.

Aitken Prize

The Aitken Prize is for the best contributed talk by a student at the Colloquium. The Prize was awarded to Jesse Hart (University of Auckland) for the talk *Notions of transfinite diameter on affine algebraic varieties*.


Left: Jesse Hart receiving the Aitken Prize from Astrid. Right: Valerie Chopovda, Christian Offen, and Jesse Hart. (Photos by Chris Tuffley.)

There were three honourable mentions: Valerie Chopovda (Massey University) for the talk *Families of planar periodic orbits generated from the Schubart-likeorbit in the Caledonian four-body problem*, Christian Offen (Massey University) for the talk *Bifurcation of solutions to Hamiltonian boundary value problems* and John Griffith Moala (University of Auckland) for the talk *How do students justify the optimality of their solutions in a contextualized discrete optimization task?*

Early-Career Research Award

The Early-Career Research Award was awarded to Brendan Creutz (University of Canterbury)

> "For his outstanding work on local-global questions on diophantine equations, in particular his resolution of a 50 year old question of Cassels and the development of novel computational techniques to study the arithmetic of algebraic curves and surfaces."

Brendan Creutz receiving the Early-Career Research Award from Astrid. (Photo by Chris Tuffley.)

Research Award

The Research Award was awarded to Igor Klep (University of Auckland) for

> "deep and fundamental advances in real algebraic geometry and its application to diverse fields including operator theory, optimization, free analysis, convexity, and von Neumann algebras."

Igor Klep receiving the Research Award from Astrid. (Photo by Chris Tuffley.)

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 is for an outstanding and innovative piece of research in the mathematical sciences published by a member or members of the NZMS. The value of the Prize is $5000. It 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.

The second Kalman Prize for Best Paper was awarded to Lisa Orloff Clark (Victoria University of Wellington) for the journal article

> Jonathan H. Brown, Lisa Orloff Clark, Cynthia Farthing and Aidan Sims, *Simplicity of algebras associated to etale groupoids*, Semigroup Forum **88** (2014), 433–452.

Astrid presenting the Kalman Prize for Best Paper, awarded to Lisa Orloff Clark, and collected by Mark McGuinness on Lisa's behalf. (Photo by Chris Tuffley.)

NZMS Fellowships

NZMS Fellowships were awarded to Shaun Cooper (Massey University), Tom ter Elst (University of Auckland), Eamonn O'Brien (University of Auckland) and Ilze Ziedens (University of Auckland).

Shaun Cooper, Tom ter Elst, and Ilze Ziedens. (Photo by Chris Tuffley.)

Nominating Committee

In the past we have sought nominations or applications for various positions, awards and fellowships through individual efforts, through Council, and by asking Councillors to consult with their departments. These include NZMS prizes and awards, nominations for fellowships (NZMS and Royal Society), Council positions, committee memberships (such as judging panels for prizes), the Lectureships and IMU positions. There are always good candidates for these, but I believe that there are also many good people that don't get considered, at least in part because the nomination process happens in an ad hoc fashion.

To ensure a broad pool of nominations, Council has recently established a Nominating Committee. In spite of its name, the Committee will not nominate: instead it will identify candidates, and suggest to others that a person should be nominated or nudged to apply. (There was some concern that a nomination from this Committee might be considered more worthy than others, and we don't want this.) In particular, this Committee will be part of a framework that encourages and helps minorities to have active careers in mathematics.

The Committee will normally consist of four members of the NZMS, and will be appointed by the NZMS Council. It should include one person currently on the NZMS Council, usually the President or Vice-President. The Chair should not be a current member of Council; Hinke Osinga has agreed to be the inaugural Chair of the Committee. The Committee will start its work in 2018.

Best Practice for Judging Panels

Everyone has unconscious biases, and there are practices which help to minimise their effect. Council has endorsed some straightforward guidelines for NZMS judging panels to follow.

Acknowledgements

It has been a privilege to serve as NZMS President. There are many people who contribute to the running of the NZMS, and I am grateful to them all. In particular, I want to thank Boris Beaumer for his service as webmaster, John Shanks for his service as Membership Secretary and work on the website, Miguel Moyers-Gonzalez and Phil Wilson for their service editing the Newsletter, and Shaun Cooper for his service as Editor of the NZ Journal of Mathematics. I'm especially grateful to the members of the Council for their service, and in particular to Emily Harvey as Secretary, Bruce van Brunt as Treasurer and Vivien Kirk as Incoming President.

Astrid an Huef

MATHEMATICAL MINIATURE

MM44: Linear Algebra can be Interesting

In the 1950s it might have been necessary for computational and applied mathematicians to justify themselves to their purer colleagues by publications such as [2]. Today no one should need to apologise. Linear algebra is now part of the curriculum and it can be made approachable and computational as well as theoretical. Computers now bring us together rather than drive us apart. Search engines, like Google, on which we all depend, do enormous Singular Value Decomposition calculations and show numerical linear algebra at its most spectacular.

Timothy Swan, a gifted amateur mathematician, would not have been aware of [2], even though he would have been able to read and appreciate it, and even think beyond it. Between the pages of his notebooks were some stapled notes which he seems to have written in his last years. He even lent his notes to some Auckland academic mathematicians in the hope that they would bestow approval and encouragement on him. As his notebooks recount, he received neither approval nor encouragement. On a page, which looks as though it might have been stained with a tear, he described the scorn that was poured on what he had hoped was a result with some merit:

Theorem 1. *Let $A=\sum_{i=1}^{n}u_iv_i^T$, be an $n\times n$ matrix, where the u_i are independent and the v_i are independent. Let B be an $n\times n$ matrix with (i,j) element equal to $v_i^Tu_j$. Then A and B are similar matrices.*

In the 1950s, the MA/MSc examinations were very old-fashioned by modern standards and linear algebra questions often had an emphasis on determinants. This might seem to be a sign that New Zealand was behind the times, but our examiners were British and the scripts had to be sent to England for marking. Timothy Swan, who had never taken a proper mathematics course in his life, showed in his notes, how to solve many of the examination problems, using Theorem 1.

Another result in Timothy's notes was

Theorem 2. *Let A and $A+uv^T$ be non-singular $n\times n$ matrices. Then*

$$(A+uv^T)^{-1}=A^{-1}-(1+v^TA^{-1}u)^{-1}(A^{-1}u)(v^TA^{-1}).$$

This may not be a profound piece of mathematics but, unknown to Timothy, it was discovered at about the same time by other people and has become a useful tool in statistics and computational linear algebra. Later it opened the way to a numerical method [4] that would have been a worthy item in [2] had it been known then.

Numerical linear algebra has made many other surprising discoveries that post-dated [2]. It had always been assumed that Gaussian elimination with its $O(n^3)$ multiplication count was as good as it gets. This assumption was contradicted by the results in [3]. New Zealand's own Garry Tee became the local expert on this work.

Professor H. G. Forder, who looked briefly at Timothy's linear algebra notes, gave the opinion that his approach would have been interesting if it had led to a proof of

Theorem 3. *Given a real square matrix A, there exists two symmetric matrices S_1,S_2, at least one of which is non-singular, such that $A=S_1S_2$.*

This result was featured in [1] and that will be why Professor Forder put it forward as an interesting exercise. Even though Timothy didn't seem to have responded to this challenge, his approach, based on rank one modifications, might have turned out to have been successful. Or there might be some other simple argument. So I am now passing on this challenge from Forder to Swan to me and on to you.

J.C. Butcher
butcher@math.auckland.ac.nz

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1. *The Calculus of Extension*, H. G. Forder, Cambridge University Press, (1941).
2. Solving linear algebraic equations can be interesting, G. E. Forsythe, *Bull. Amer. Math. Soc.* **59** (1953), 299–329.
3. Gaussian elimination is not optimal, V. Strassen, *Numer. Math.* **13** (1969), 354–356.
4. Matrix inversion by the annihilation of rank, H. S. Wilf, *J . Soc. Indust. Appl. Math.*, **7** (1959), 149–151.

CYBERMATH

As the deadline for each column approaches, I hope to write about something other than journal publishing, but lately there has been so much news from that direction that it is hard to ignore.

In 2014 Timothy Gowers and others used Freedom of Information laws to discover the amounts paid by UK universities for journal subscriptions to Elsevier. The reason they did this was that Elsevier (and SpringerNature, and maybe other publishers) insist very strongly on confidentiality agreements when they sign contracts with universities. The presumed reason for such insistence is that this makes their job of profit maximization much easier by lowering the bargaining ability of the universities.

The UK data showed that not only was each university spending a large amount, these numbers varied substantially even between universities with very similar size and research profile.

Earlier work in the USA and later work in Finland and the Netherlands has confirmed this overall picture. In 2014 I wrote to all NZ universities except Lincoln (for no really good reason, and I should rectify this, although it is only 1/4 the size of the next smallest university), requesting information of subscriptions paid to Elsevier, Springer, Taylor & Francis, and Wiley (the first three are actually divisions of larger companies RELX, SpringerNature, Informa). These are the top four publishers in terms of expenditure by most libraries, although they account for considerably less than half of total journal expenditure. The universities concerned have around 8,400 EFT academic/research staff and 130,000 EFT students.

As expected, all the universities refused, and it was clear from the similarity of their answers that they had help from the publishers. Unlike the situation in UK there was no right of review of these refusals at a university level, so I complained next to the Ombudsman, citing the Official Information Act 1982.

After over three years of delays of all types, the Ombudsman's final report figshare.com/articles/Ombudsman_s_final_opinion/5673583 unambiguously ruled in my favour, and the universities eventually supplied the information. So now we know how much they have spent, and the results are illuminating. Because of the fact that payments were made in various currencies, I have had to make some assumptions on exchange rates based on historical data. The raw data is available on Figshare figshare.com/articles/Universities_final_replies/5656054.

- For just these four publishers, the seven universities paid NZ$19.4 million in 2016 in order to rent access to journal articles.
- This amounts to $2,300 per academic/research staff member.
- For comparison, the Marsden Fund awarded $84.6 million this year, a big increase on previous years.
- In the period 2013–2016, the amount paid rose by 17%, whereas CPI inflation in NZ and most other developed countries was around 3% over that period.

Longtime readers of this column will have no doubt about my opinion on these data. A huge waste of public money is occurring — independent estimates of the real cost of production of journal articles by modern publishers put it around US$500 per article, at most, while the current setup yields income 10 times that for the large publishers. These publishers make profits of around 40%, unmatched in any other legal industry.

The big publishers realise that the current subscription model is not sustainable. Although the way they market journal bundles — "Big Deals" — helps to insulate them from cancellations, such cancellations by academic libraries are slowly increasing, because the cost increases year on year are simply too much for budgets to bear. The publishers have seized upon the author-pay open access model as a way to protect their revenue. This model has serious resistance from researchers in fields such as mathematics.

Readers interested in learning about how we got to such an unpleasant situation should read this article. Readers interested in helping to get us out of the situation could do worse than to contact me at info@mathoa.org.

Mark C. Wilson

MATHEMATICAL MISEPONYMY

Cantor's Ternary Set

Most of us who have met Cantor's Ternary Set did so in analysis or topology courses either at the advanced undergraduate or early graduate level. Recall that it is obtained from the closed unit interval $[0,1]$ by inductively removing open intervals: firstly the open middle third $\left(\frac{1}{3},\frac{2}{3}\right)$ to be left with two closed intervals then at the n^{th} stage having 2^{n-1} closed intervals we remove the open middle thirds of each. Cantor's Ternary Set is what is left after the removal process goes through all of the natural numbers[1]. It has this eponymous title because of its description in [2].

In [3, Chapter 2] there is a description of mathematicians' struggles in the 1870s to understand when discontinuous functions might be Riemann integrable. While most of the mathematicians involved were based in Europe, one mathematician based in Oxford was also interested in these problems, though he is better known for his work in Number Theory and the Smith normal form for a matrix. He was Henry John Stephen Smith.

In [5, p. 147], with a nominal published date 10$^{\text{th}}$ June, 1875, Smith describes a subset of $[0,1]$ in the following manner:

> Let m be any given integral number greater than 2. Divide the interval from 0 to 1 into m equal parts; and exempt the last segment from any subsequent division. Divide each of the remaining $m-1$ segments into m equal parts; and exempt the last segment of each from any subsequent division. If this operation be continued *ad infinitum*, we shall obtain an infinite number of points of division P upon the line from 0 to 1.

Smith was interested in the integrability of a function that was continuous except at the "points of division" described above. Smith went on to show that the measure of P is 0, so a function continuous except on P is Riemann integrable. Actually his argument also applies to the closure of P, $\overline{P}$. Some points of P, such as 1 and $\frac{m-1}{m^2}$, are isolated while others, such as 0 and $\frac{1}{m}$, are limit points of P. Of course all points of $\overline{P}\setminus P$ are limit points, for example $\frac{m-2}{m-1}$ and $\frac{1}{m^2-1}$.

What is S, the set of limit points of P? I'll just look at the case $m=3$. Notice that all points of $P\cap\left(\frac{1}{2},1\right]$ are of the form $\frac{1}{2}+\frac{1}{2\times 3^n}$ for $n=0,1,2,\ldots$, so are isolated and hence not in S, so $S\subset\left[0,\frac{1}{2}\right]$. Similarly all points of $P\cap\left(\frac{1}{6},\frac{1}{3}\right)$ are of the form $\frac{1}{6}+\frac{1}{6\times 3^n}$ $(n=1,2,\ldots)$ and hence are also not in S. Continuing thus we see that S is just Cantor's Ternary Set squeezed by a factor of $\frac{1}{2}$. So should Cantor's Ternary Set really be called Smith's set?

These ideas were also considered by Paul du Bois-Reymond and Vito Volterra, see [1] and [6][2] respectively but it seems that, like Cantor, these mathematicians were unaware of Smith's earlier work, though [6] does cite [1].

Maybe even Smith, du Bois-Reymond, Volterra and Cantor were beaten to the set by the ancient Egyptians! When Napoleon and friends tried to conquer Egypt they took along folk to study ancient monuments, leading to [4]. The twelfth picture at the url given in [4] below is this:

Compare with my first paragraph!

David Gauld

[1] It is the set of all numbers in $[0,1]$ for which there is a ternary expansion consisting solely of 0s and 2s: in base 3, for example, $\frac{1}{4}=0.02020\ldots$ and $\frac{1}{3}=0.100\ldots$ but $\frac{1}{3}$ is also $0.02222\ldots$ so $\frac{1}{4}$ and $\frac{1}{3}$ are both in the set.

[2] Maybe it is worth noting that Volterra's paper was received in February 1880 when the future Senator Volterra was still 19 years old.

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[1] Paul du Bois-Reymond, *Der Beweis des Fundamentalsatzes der Integralrechnung*, Mathematische Annalen, **16**(1880), 115–128.

[2] Georg Cantor, *Über unendliche, lineare Punktmannigfaltigkeiten*, Mathematische Annalen, **21**(1883), 545–591.

[3] Thomas Hawkins, *Lebesgue's theory of integration*, The University of Wisconsin Press, Madison, Milwaukee, London, 1970.

[4] Jean-Baptiste Prosper JOLLOIS (delineavit), Edouard DEVILLIERS (delineavit), *Description de l'Egypte. Ile de Philae. Plan, coupe, élévation et détails de trois chapiteaux de l'édifice de l'est* (Antiquities, volume I, planche 26), Imprimerie Impériale, Paris 1809–1829. See https://www.edition-originale.com/en/travel/africa-and-arabic-world/jollois-description-de-legypte-ile-de-1809-25929.

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[6] Vito Volterra, *Alcune osservazioni sulle funzioni punteggiate discontinue*, Giornale di Matematiche, **19**(1881), 76–86.

THE AUCKLAND PROMPTUARY

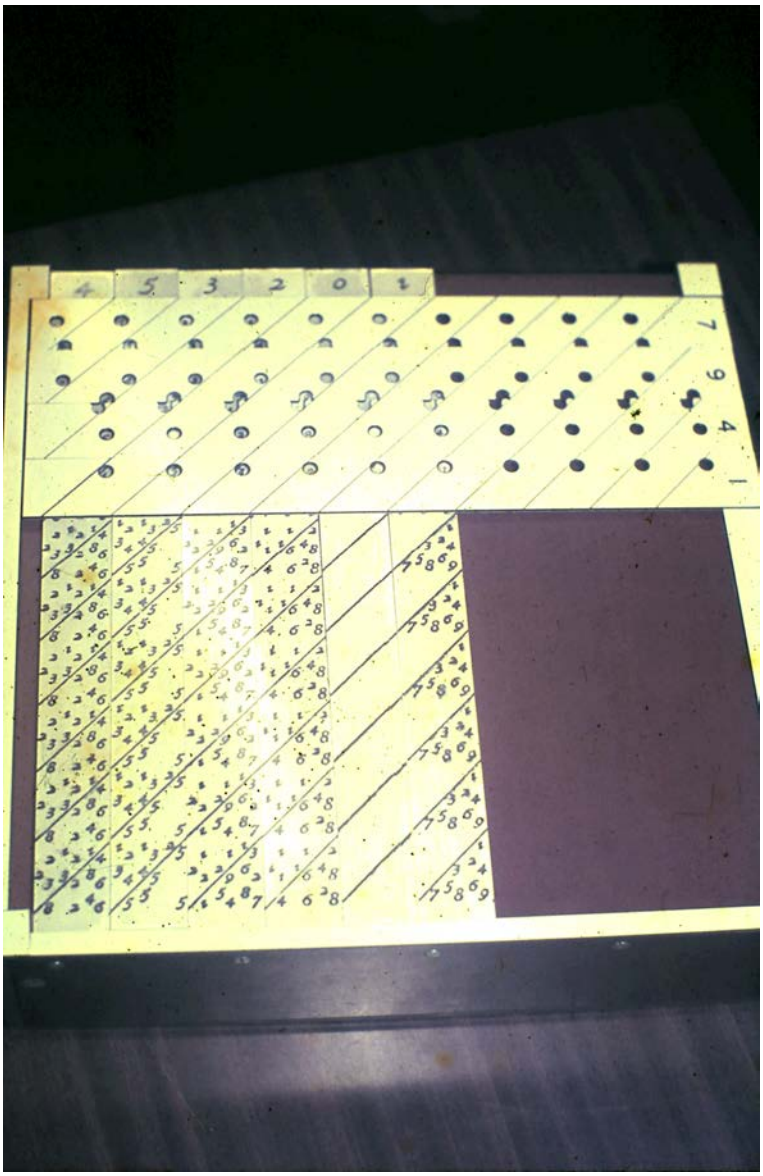
John Napier, 1616, Lord Napier and Ettrick.

John Napier (Laird of Merchiston, 1550–1617) published his invention of logarithms at Edinburgh in 1614, and the mathematicians of Europe instantly acclaimed him as the greatest of them all. Absolutely no scientific work had previously been done in Scotland.

In 1617 Napier published his small book **Rabdologiæ** in Edinburgh. That describes his inventions of a pocket–size decimal multiplication table (Napier's Bones), binary arithmetic (as far as square root extraction) and his Promptuarium Multiplicationis (Lightning Calculator). That was the first calculating machine: an almost-wholly mechanical multiplier for numbers with up to 10 digits each, giving the exact product (up to 20 digits). It displayed conveniently the pair of digits for each product of digits from the 2 numbers being multiplied, with the user mentally adding the single-digit numbers displayed. Napier's Promptuary was almost completely ignored. Very few mentions of it got published, and almost all of those confused it with Napier's Bones (which are trivial).

At the University of Auckland, I supervised a mature student William Francis Hawkins for his Ph.D. (1982) on *The Mathematical Work of John Napier*. When Hawkins translated **Rabdologiæ** from Latin to English, neither of us initially could understand the Promptuary. When I did succeed in understanding Napier's account, my admiration of Napier as a brilliantly original mathematician was greatly enhanced. I told Hawkins "Look — the Promptuary is too important to remain as an Appendix in your thesis. Let's build one!". Ray Myer (Dean of Engineering) agreed to get the Engineering technicians to build a Promptuary from Hawkins's English translation. Napier declared that the 20-digit product of a pair of 10-digit numbers could be produced in less than a minute by using the Promptuary. Hawkins and I found that, after a little practice, we both could do that in 45 seconds.

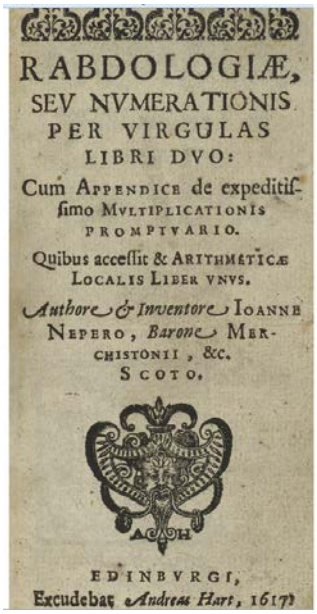
Hawkins first publicly demonstrated the Auckland Promptuary at the 1979 NZ Mathematics Colloquium (University of Waikato). His article "The first calculating machine (John Napier, 1617)" was published in *NZMS Newsletter* No.**16** (1979) Supplement, 1–23; and it was reprinted (with two photographs) in "The Promptuary



The Auckland Promptuary, set up to multiply 453201 by 7941.

Papers", *Annals of the History of Computing* (1988) vol.**10**, 35–67. I reviewed Hawkins's 1979 paper in *Mathematical Reviews* 80k:01023:

> In the last year of his life, John Napier (1550–1617) published his Latin book *Rabdologiæ* in which he explained that, since he had published his invention of logarithms in 1614, he had developed other methods for simplifying calculations. He described several aids to computations (including the first full publication of binary arithmetic, as far as square root extraction), but the only one to become popular was his elementary device of numbered rods (Napier's bones) to assist in multiplication. Napier wrote that the most important concept in his book was his "Promptuary", a machine for multiplying numbers of up to 10 digits each (with straightforward extension to larger numbers). The specification was published 6 years before Wilhelm Schickard told Kepler (on 20 September 1623) of his calculating machine, which incorporated some ideas from *Rabdologiæ*. Napier explained carefully how to reduce the division of x by y to the multiplication of x by the reciprocal of y, found from trigonometric tables or from special tables of reciprocals.
>
> The Promptuary is a mechanization of the Arabian lattice method of multiplication. To multiply x by y, for each consecutive digit of x a corresponding "direct strip", inscribed with multiple copies of a compact table of multiples of that digit, is laid consecutively across the top of a box. Then, for each


RABDOLOGIÆ,
SEV NVMERATIONIS
PER VIRGULAS
LIBRI DVO:
Cum Appendice de expeditiſſimo Multiplicationis promptvario.
Quibus acceſſit & Arithmaticæ Localis Liber vnvs.
Authore & Inventore Ioanne Nepero, Barone Merchistonii, &c.
Scoto.
EDINBVRGI,
Excudebat Andreas Hart, 1617.


Merchiston Tower photographed on completion of the restoration in 1961. (Courtesy of the Royal Commission on the Ancient and Historical Monuments of Scotland).

Left: **Rabdologiae** title-page, 1617. Right: Merchiston Tower, from Brian Rice *et al*, **The Life and Works of John Napier** (2017), p.969.

> consecutive digit of y a corresponding "transverse strip", pierced with peepholes, is laid consecutively down on top of those strips. The peepholes display every 2-digit product of digits from x and y in the manner of the Arabian lattice. The Promptuary is not wholly automatic — the user evaluates the digits of the product (right to left) by mental addition of 1-digit numbers displayed between lines engraved at 45° to both types of strip (and also adds the carry digit), with the sum never exceeding 2 digits. The box serves as an ordered store for the strips.
>
> Napier wrote of the Promptuary in a manner which implied that he had used one; but very little notice had ever been taken of that invention, and there were strong grounds for believing that no Promptuary had existed since his lifetime. Hawkins's translation of Napier's complete specification of the Promptuary is published in this paper. That translation has been used by technicians of the School of Engineering at the University of Auckland to construct a working Promptuary, with Napier's excellent diagrams being incorporated directly into the machine. The author confirms that two 10-digit integers can indeed be multiplied in less than a minute, as Napier affirmed.

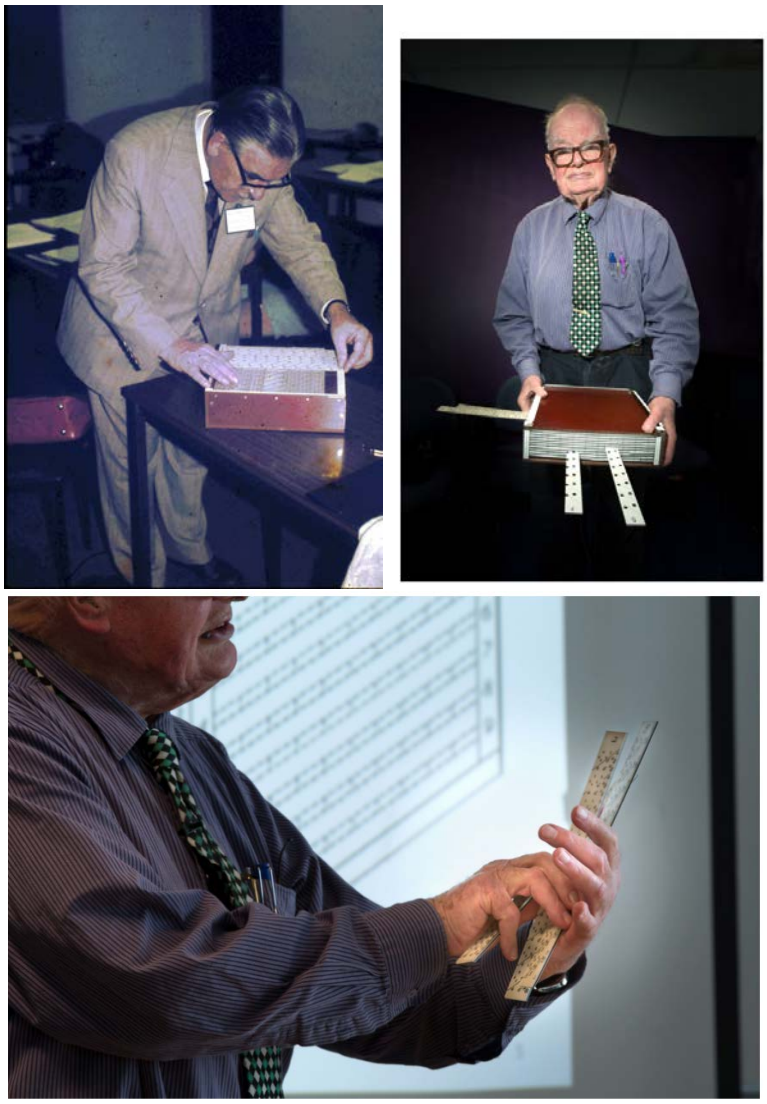
And a similar review was published in *Computing Reviews* (February 1980), as Review 35,753.

My paper on "Twentyfive years of New Zealand Mathematical Colloquia" (in *NZJM* vol.21 (1992), 145–160) gives a brief account of the Promptuary, with my photograph of Hawkins demonstrating the Auckland Promptuary at the 1979 NZ Mathematics Colloquium.

In 1980 Hawkins (then a vigorous youngster of 74) carried the Auckland Promptuary (c10kg) and demonstrated it at various universities in England, Scotland and the USA. At the University of Edinburgh the Department of Mathematics was so impressed that they published a set of 10 large posters about John Napier, with the Auckland Promptuary featured prominently. Several universities ordered similar Promptuaries from the School of Engineering — but the cost of making the Auckland Promptuary was much higher than anticipated, and the Dean would not agree to manufacture any more of them.

At Edinburgh in 1914 the 300th anniversary of Napier's publication of logarithms was celebrated by a major international conference, and in 2014 a smaller conference celebrated the 400th anniversary. And on 2017 April 4, the 400th anniversary of Napier's death was commemorated by a ceremony in Edinburgh.

Brian Rice, an eminent marine architect in England, is descended from John Napier. I have been assisting him in his project to publish the first Collected Edition of John Napier's works. His large book **The Life and Works af John Napier** (with Enrique González-Velasco & Alexander Corrigan) with all of Napier's works (his Latin books translated into English) and the fullest biography of him which has been written, has now been published (in 994 pages) by Springer.



Top left: William Francis Hawkins demonstrating the Auckland Promptuary, 1979. Top right: Garry Tee, holding the Auckland Promptuary (Godfrey Boehnke). Bottom: Close view of strips (Godfrey Boehnke).

Napier University in Scotland was named after John Napier, and his castle at Merchiston (west of Edinburgh) is the centre of its Merchiston campus. I have now arranged for the University of Auckland to present the Auckland Promptuary to Napier University, in commemoration of John Napier.

I demonstrated the Auckland Promptuary on Wednesday August 16th, at a joint seminar of the Department of Mathematics and the Department of Computer Science. At the end I brandished a letter from the Vice-Chancellor of Napier University which had arrived that morning, thanking me warmly for arranging that gift from the University of Auckland to Napier University.

After that the Auckland Promptuary was packed securely in a box, and collected by a courier who delivered it to the Merchiston campus, where it will be prominently displayed.

Reprints of the articles mentioned herein are available upon request.

Garry J. Tee

tee@math.auckland.ac.nz

PROFILE

Clemency Montelle

Clemency Montelle grew up in the beautiful Garden City, Christchurch. She enrolled at the University of Canterbury but having no idea what to study, she decided on Mathematics as she had loved it at school, and on Greek and Latin because she was fascinated by ancient scripts and the complexities of inflected languages. In her fourth year, while browsing the library shelves for a Greek essay, Clemency came across Euclid's Elements in ancient Greek, a text that she was surprised to find united her interests. This proved to be a "lightbulb moment" for her, in which she realised that she could read about mathematics and science in other languages and rediscover ancient insights. This experience highlighted for Clemency the value of physical libraries, as well as setting her on a new interdisciplinary path.

After finishing her BA(Hons) she won a Fulbright scholarship to Brown University in Providence, Rhode Island, in the USA. Her PhD was in the History of Mathematics Department, where she read ancient mathematical texts in Greek, Latin, Sanskrit, Arabic, and Cuneiform and examined their mathematical content. These ancient languages are important for understanding not only the rich Asian and Middle Eastern, but also the European scientific traditions. Although many Latin and Greek texts have been lost in their original forms, they were translated into Arabic over a thousand years ago and can be recovered today. As Clemency points out, the so-called 'Dark Ages' did not occur everywhere and Arabic, Indian and Chinese science continued to flourish during periods when European traditions stalled.

Clemency's research draws together history, mathematics and ancient languages to understand how India has contributed to global science. As she highlights, "many histories of science have centred on the so-called 'western miracle' in their analysis of the ignition and flourishing of modern science, [but] they have done so at the expense of other non-European traditions." Her research aims to rebalance our understanding of the history of science. India is of particular interest because it is the direct scientific heritage of around one sixth of the world's population. The cultural context in which mathematics was done in India was also quite different from our own, hence the fascination to uncover the diverse ways in which early peoples practised mathematics.

The frequent neglect of the non-European history of scientific development motivates Clemency's research. Together India and China hold around a third of the world's population and have been resurgent global powers

in recent decades. These regions also have expansive histories, and long traditions of intellectual enquiry. The number of surviving manuscripts has been estimated to be in the millions, many of them scientific. Yet these regions' histories, especially in the sciences, are frequently underappreciated by those outside of them. Many scientists lack the linguistic skills necessary to interpret historical scientific texts, while linguists may be daunted by the mathematics contained within.

In 2010, Clemency received a Marsden Fund Fast-Start grant to help bridge this gap. Her project examined the development of computational procedures and mathematical tables in Sanskrit through the second millennium. Clemency states that this grant was validation of the importance on focusing on India, as well as an important personal endorsement for her scholarship. Through this grant, she was able to undertake extended research in the libraries and archives of India, build international collaborations from South Asia to France, and publish widely on Mughal and Indian astronomy, mathematics, and scientific methods.

Building on this success, Clemency was awarded a five-year Rutherford Discovery Fellowship in 2012. This fellowship has allowed her to return to India for further research into mathematical, astronomical, and scientific manuscripts.

Recently, Clemency was part of an international group of academics that challenged Oxford University's findings about the use of zero in an ancient Indian manuscript. They argue that the work written on the leaves of the Bakhshali manuscript is a unified treatise on arithmetic that must have been written at the time of the latest of the manuscript's leaves, not the earliest. Contrary to the different dates the radio carbon dating suggests, the treatise shows no signs of being a jumble of fragments from different periods, the academics say. Both the handwriting and the topic being discussed are continuous across the boundary of the first two dated leaves. It looks very much as if the scribe, who may have lived at the end of the eighth century, wrote out his treatise on a group of leaves that had been manufactured at very different times. But of greater significance for the history of mathematics is the authors' evidence showing that the Bakhshali treatise does indeed know the "true" zero, and contains calculations like long multiplication that would have necessitated using zero as an arithmetical number. From various other features of the manuscript's style and content, the team concludes that Oxford's claims are implausible and do not fit with what has previously been discovered about the Bakhshali Manuscript.

More generally, Clemency's research seeks to reintroduce Indian scientific traditions into the history of science. Throughout her research in India, Clemency has sought to build local connections and capacity, joining a movement to encourage local knowledge of the subcontinent's impressive intellectual traditions. She works closely with the Chennai Mathematical Institute and the Indian Institute of Technology in Mumbai to increase scholarship and teaching of the history of science. She also co-founded the History of Astronomical and Mathematical Sciences in India (HAMSI) working group, which brings international scholars together, mostly recently in Christchurch.

Clemency hopes her research will help make mathematics and the history of science more accessible to scholars and students. She uses her unique approach to maths as a way to humanise the STEM subjects, and to draw new students to these disciplines. She notes that "maths is not culture-free", and that highlighting science's diverse history can attract people who might not fit the bill of the stereotypical STEM student. As technology companies and academic departments continue to struggle with diversity, this remains an important mission.

Kate Stevens (RSNZ), Margaret Agnew (University of Canterbury), Miguel Moyers González (University of Canterbury)

LOCAL NEWS

AUCKLAND UNIVERSITY OF TECHNOLOGY

SCHOOL OF ENGINEERING, COMPUTER AND MATHEMATICAL SCIENCES

Events

On 23–24 November, the Mathematical Science Research Group (MSRG) organized the 2017 AUT Mathematical Sciences Symposium. This is a joint effort of Professors Jiling Cao and Jeffrey Hunter, with the assistance of Drs Sarah Marshall, Nuttanan Wichitaksorn and Wenjun Zhang. The symposium focuses mainly on some areas in Applied Mathematics and Analytics/Statistics. This main purpose of this annual event is to develop and promote opportunities for AUT academic staff working on these areas to collaborate with colleagues from other universities.

Travel and Conference Participation

Prof. Jeffrey Hunter has been visiting India to take up a number of invitations — Keynote Speaker at the 2nd International Conference on "Recent Advances in Mathematical Sciences and its Applications" (RAMSA-2017) held over December 12–14, 2017 at Jaypee Institute of Information Technology, Noida, New Delhi. Speaking on the first day he was also able to fly the next day, via Mumbai and Mangalore , to accept an invitation to be an Invited speaker at the "International Conference on Linear Algebra and it Applications" (ICLAA-2017) held over Dec 11–15. He had a number of other invitations including the opportunity to be a Keynote speaker at the International Conference on Advances in Mathematical Sciences (ICAMS-2017) organised by the Department of Mathematics, VIT University, Vellore over Dec 1–3, 2017. He wasn't able to accept this invitation but accepted their invitation to be part of their International Advisory Committee and agreed to visit and deliver two guest lectures at Vellore on Dec 19, the day he flies out of Chennai International Airport to return home. He was also accompanied with his wife Hazel who as Past New Zealand President of Inner Wheel and a past International Board member was able to accept invitations to be hosted at a number of locations including Shimla, Ambala and Chennai. Jeff also caught up with Jai Pal Singh in Delhi who visited Massey University in the 1990's. A very busy programme for them both.

Over the period of November 13–17, Prof. Jiling Cao attended the 2nd Pan-Pacific International Conference on Topology and Applications (PPICTA), held in Busan, South Korea. He was a member of the conference scientific committee and also a guest-editor of the conference proceedings. The PPICTA, usually attracts about 250 participants, is a biennial conference that brings together researchers from topology and various application areas to discuss recent key achievements, new problems and future directions for research, and also helps promoting the academic exchange and the friendship among researchers on this area and related topics. The inaugural conference, organized by Prof. Cao, was held in November 2015 at Minnan Normal University, Zhangzhou, China.

Dr. Hyuck Chung travelled to Dunedin in November 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. The collaboration has led to several publications. In February 2018, Hyuck will host The 3rd Australasian Conference on Wave Science at AUT: aut.ac.nz/study-at-aut/study-areas/engineering-computer-and-mathematical-sciences/news-and-events/events-folder/the-3rd-australasian-conference-on-wave-science

Dr. Kate Lee is taking a research leave for the second semester in 2017. She has been visiting the university of Oxford in UK and Université Paris-Dauphine in France. She will give an invited talk at the 2017 International Workshop on Objective Bayes Methodology (10–13 December 2017) in Austin, US.

Dr. Nate Wichitaksorn is planning to attend the Sixth Wellington Workshop in Probability and Mathematical Statistics (WWPMS 2017) that will be held at Victoria University of Wellington on 4–6 December 2017. The workshop has approximately 20 invited talks by speakers from Australia, Canada, France, New Zealand, etc.

Dr. Wenjun Zhang is attending the Quantitative Methods in Finance 2017 Conference held on 12–15 December 2017 in Sydney. The conference will bring together leading experts in quantitative finance industry and academia in Australia and New Zealand. Wenjun will also take part in the 2017 Auckland Financial Meeting held in Queenstown on 18–20 December. Wenjun will present talks in both of the conferences.

Wenjun Zhang

UNIVERSITY OF AUCKLAND

DEPARTMENT OF MATHEMATICS

John Butcher had been honoured on his 60th birthday (in 1993) by the first of the SCADE conferences (now known as SciCADE), that began here. The subject of Scientific Computation and Differential Equations has had an enduring significance and this series of meetings has been held every two years, always in a different

A/Prof. Ilze Ziedins and Dr. William Godsoe presented talks at the symposium.

part of the world, right up to the present day. SciCADE 2017 was held in Bath, England. John is probably the only person who has been to every one, although Taketomo Mitsui told John that he has been to all except one SciCADE. Over the years there has been an evolution in the breadth of the range of topics, and that is good to see. There has also been a strengthening in the algebraic and combinatorial theory behind the analysis of numerical methods. John was gratified to note that the winner of the Butcher Prize (for the best student talk) was very much in this tradition. Several of the minisymposia and one of the plenary lectures were also within the B-series/Hopf Algebra topic. Several new types of trees and several new Hopf algebras have now appeared, with a variety of scientific applications. The Hopf Algebra which numerical analysts call H_{BCK} (where the C and K are Connes and Kreimer) is now joined by H_{MKW}, where W is the former Auckland student Will Wright.

Sina Greenwood has received a Faculty Equity Fund Award.

Pedram Hekmati has received a Marsden Grant (Fast Start) of $300,000 for his project on "Exploiting gauge theory and duality in geometry".

Vaughan Jones will give a short course again in 2018, following the format of previous years, as follows. Time: two hours in the mornings of 12 to 15 February 2018 (with coffee/refreshment break) Title: The importance of being Hilbert Schmidt. Vaughan says that the course "would be accessible to anyone with a first course in analysis under their belt, and preferably also a first course in functional analysis".

Jari Kaipio leads the Inverse Problems Group at the Centre of Excellence of Inverse Modelling and Imaging in The Academy of Finland. That Centre consists of a large number of research groups, the largest of which is the Inverse Problems Group. For the third time, the Academy has selected that Inverse Problems Group as one of its Centres of Excellence.

Igor Klep has received a Marsden Grant of $455,000 for his project on "Free Analysis and its Applications".

Julia Novak was awarded a 2018 CLeaR Fellowship in Teaching and Learning.

Hinke Osinga is the 2017 recipient of the Moyal Medal, which is awarded annually by Macquarie University for research contributions to mathematics, physics or statistics, the areas of research of the late Professor José Enrique Moyal. Hinke will present a lecture and receive the award on 2 November.

Claire Postlethwaite has received a Faculty Equity Fund Award, an FRDF Postdoctoral Fellowship and a Marsden Grant of $545,000 for her project on "Noisy networks: understanding how stochasticity affects mathematical models of cognitive systems".

Thorsten Scheiner, who is finishing his PhD from University of Hamburg and Macquarie University, has joined us as a temporary lecturer for 18 months. In Semester 2 for 2017, he taught MATHS 108 and MATHS 712.

James Sneyd features on page 5 of *The University of Auckland UNINEWS* (August 2017), in an article "Adventures Across Worlds" by Julianne Evans, about a new book by Prof. Alison Jones and Prof. Kuni Kaa Jenkins: **Tuai: A Traveller in Two Worlds** (Bridget Williams Books, 2017). Tuai was a Ngare Raumati chief at the Bay of Islands, who was born in about 1797 and died in 1824. In 1817 he went to England (with his companion Titere) "to explore the world and its riches and bring them back to his people". Tuai and Titere became celebrities in High Society. The article tells that

> An important connection was made by chance, with Professor James Sneyd from the University's maths department, who

was doing his own family research in England. "James came across a diary belonging to his aristocratic ancestors, written in London in 1818, which told of New Zealanders at a 'Grand Cannibal Dinner' in London", says Alison.

This diary proved to be a treasure trove of information about how the two young Māori men were received in polite English society, where they were exotic guests. The diary describes Titere as 'a considerable dandy who has his neck confined with a black stock and high shirt collar which obliged him to turn his whole body with his head. He has many savage features ...'.

Over dinner, writes Alison, 'Tuai and Titere entertained the English guests by discussing culinary matters. Both men liked pepper on all the food and Titere boasted that he could eat anything. But he couldn't stomach the sour cranberry tart'.

Both men got ill in London and moved to Shropshire, where they witnessed the Industrial Revolution at first hand: huge furnaces making molten iron, factories producing glass, ceramics and massive ropes ⋯ .

Tuai was not the first Māori to travel to England in the early 1800s, says Alison, but he was of the first generation of Māori "to travel confidently overseas from a country still dominated by traditional culture and ancient ways".

Being curious and ambitious. Alison says, Tuai's biggest hope was that he could somehow make use of all the technological advancements of the industrial age, particularly its superior weaponry, to help his people, who were facing the expansion of their rivals Ngāpuhi.

Several members of our Department received awards at the 2017 NZMS Colloquium dinner.

Jesse Hart received the ANZIAM Prize for best poster with his poster 'Notions of transfinite diameter on affine algebraic varieties'. Susan Yang received an honourable mention for her poster 'Dynamics of a coupled calcium system'.

Jesse Hart also received the Aitken Prize for best student presentation with his talk 'Transfinite diameter on affine algebraic varieties'. John Griffith Moala received an honorable mention for his talk 'How do students justify the optimality of their solutions in a contextualized discrete optimization task?'

The NZMS Award for Mathematical Research was awarded to Igor Klep for 'deep and fundamental advances in real algebraic geometry and its application to diverse fields including operator theory, optimization, free analysis, convexity, and von Neumann algebras'.

Eamonn O'Brien and Tom ter Elst were accredited as Fellows of the NZMS 'in recognition of their contributions to mathematics and their professional standing in the New Zealand mathematical community'.

Recent visitors include: Prof. Guy Boyde (University of Southampton), Professor Emeritus Jon Carlson (University of Georgia, Athens), Ms Jiali Du (Visiting PhD student from Beijing Jiaotong University), Dr Antoine Dujon (Deakin University), Dr Willem Fouché (University of South Africa), Mr Jordan Frost (University of Bristol), Prof. Ademir Hujdurovic (University of Primorska), Prof. Charles Leedham-Green (Queen Mary, University of London), Mr Christian Offen (Massey University), Prof. Ken Ono (Emory University & MacLaurin lecturer), Prof. Larry Peterson (University of North Dakota), Dr Aki Pulkkinen (University of Eastern Finland), Dr Cami Sawyer (Massey University), Prof. Anastasiia Tsvietkova (OIST, Japan & Rutgers, USA), and Prof. Rachel Weir (Allegheny College, USA).

Garry J. Tee

DEPARTMENT OF STATISTICS

Professor James Curran will be Head of the Department of Statistics from next February, for a four-year term. James, who succeeds Associate Professor Ilze Ziedins, will be responsible for academic and professional leadership, budgets, teaching and staff in Australasia's largest statistics department. He will also be the liaison between the department and the overarching Faculty of Science.

James says his game plan is "to make sure we stay strong as a department, and as leaders both in the Australasian region as well as globally. Turnover due to retirement will continue to be an issue, and we will need a constant flow of new staff."

For more on the new HoD see: science.auckland.ac.nz/en/about/news/news-2017/09/professor-james-curran-takes-the-lead.html.

Retirement: Professor Chris Wild — Visualising the future

Professor Chris Wild says going part-time as a lengthy prelude to retirement will allow him to "indulge his passions". He's not talking about putting his feet up here; rather, Chris wants to spend more time looking at "what software can do for teaching and the statistical empowerment of society at large; broadening what you can see in data and reducing the time it takes to be able to see it".

More on Chris's retirement here: stat.auckland.ac.nz/en/about/news-and-events-5/news/news-2017/2017/10/professor-chris-wild-visualising-the-future.html

New Staff

The department welcomes Claudia Rivera Rodriguez and Rhys Jones as new staff to the department.

Claudia had finished her PhD in the department before leaving for a post-doctoral role at Harvard University, working with medical and public health researchers. Claudia is excited about returning to the department as a lecturer, where she is continuing to work on the design and analysis of studies based on samples from existing databases. More on Claudia: stat.auckland.ac.nz/en/about/news-and-events-5/news/news-2017/2017/09/claudia-rivera-rodriguez-drawn-back-to-auckland.html.

Rhys has joined us as a Professional Teaching Fellow to increase student engagement with statistics and curriculum development. Rhys, from Wales, has degrees in biology, medical biochemistry, immunology and teacher training. In his 10-year career, he has held lecturing positions in London South East College and Birmingham City University (BCU), teaching mostly undergraduate courses in analytical and inorganic chemistry, microbiology, biomedical science, nutrition and organic chemistry, mathematics for science, health and wellbeing, genetics, and clinical anatomy and physiology. As a lecturer in quantitative methods at the Cardiff University School of Social Sciences, he set up several national courses in interdisciplinary statistics with a group of teachers across several curriculum areas for Year 11–13 students. More on Rhys: stat.auckland.ac.nz/en/about/news-and-events-5/news/news-2017/2017/10/light-bulb-learning-moments-in-statistics.html.

More

For more exciting stories from the department like what our PhD students are up to, how Renate Meyer's research relates to the recent Nobel Prize in Physics, or Rachel Fewster's latest outreach project CatchIT, visit the department's events page: stat.auckland.ac.nz/en/about/news-and-events-5/news/news-2017/.

Atakohu Middleton & Steffen Klaere

UNIVERSITY OF WAIKATO

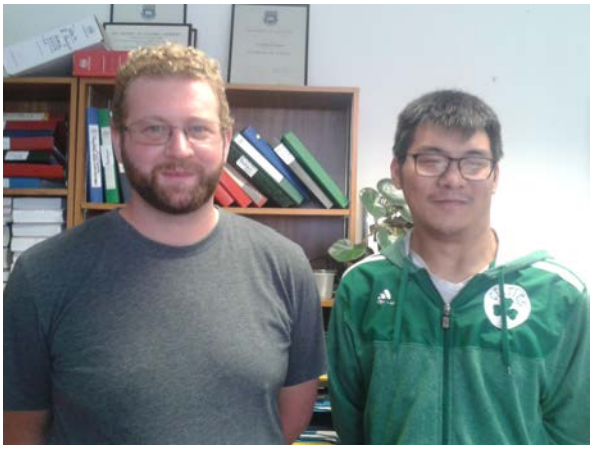
DEPARTMENT OF MATHEMATICS AND STATISTICS

The upcoming Kalnins Fest

The *6th annual meeting of the Australian and New Zealand Association of Mathematical Physics* will be held at the University of Auckland commencing on 30th January. Of particular note is that the 2nd February will be dedicated to a celebration of the career of Professor Ernie Kalnins in an event titled *Harnessing hidden symmetry — geometry and superintegrable systems*.

Hamish Gilmore and Chris King

The conference *Number Theory Down Under 5* was held at La Trobe University (Bendigo Campus) in September/October this year. Two Waikato PhD students of Daniel Delbourgo received certificates for highly commended student talks: Hamish Gilmore for *Computing $\mathscr{L}$-invariants for the symmetric square of an elliptic curve*, and Chris King for *K_1-congruences for the three-dimensional Lie groups*.



Hamish Gilmore and Chris King.

Nick Lim

The NZ Mathematics and Statistics Post Graduate Student Annual Conference, was held at Kaiteriteri beach (Nelson/Motueka region) in November. The Waikato Statistics PhD candidate Nick Lim won the prize for the best statistics presentation, and overall award with his talk entitled: *Meeting the modern Prometheus: an introductory look into the inner working of deep learning.*

Alfred Sneyd

We regret to report that Alfred Sneyd continues with his serious health issues, and recently moved from home to Radius Kensington in Hamilton.

Noted in passing

Graham French died in May this year aged 78 years. He joined the Department of Mathematics and Statistics in 1969 after graduating from the University of Auckland and spending a period working for the DSIR. John

Nick Lim.

Kalman always spoke very highly of his abilities as a mathematician. He retired in 1998 and followed this with a period as a Senior Tutor. When this appointment came to an end he left Hamilton, first to Te Aroha and then north of Auckland.

We also note the passing of Desmond Sawyer in April this year, aged 92 years. Desmond was the first Deputy Vice-Chancellor at Waikato and head of mathematics for 5 years following the establishment of the university in 1964. After that he returned to the University of Otago.

Big birthdays

Desmond Sawyer was followed by A. (Teddy) Zulauf as professor of Mathematics who came to Waikato from the University of Sierra Leone at the end of the 1960s. Last year he celebrated his 90th birthday and is still in good health and living in Hamilton. The same can be said for John (JC) Turner, who will celebrate his 90th birthday next year. He is still mathematically active in research and teaches in the Waikato U3A programme.

Books published

We celebrated the publication of the two volume work *Equivalents of the Riemann Hypothesis, CUP, 2017* by B at a book launch in the Faculty of Computing and Mathematical Sciences earlier this month. Ken Ono spoke of an exciting new equivalent when he visited Waikato in October — this will be accessible via the website `math.waikato.ac.nz/~kab/ERH/EquivRH.html` once it has been published.

Kevin Broughan

MASSEY UNIVERSITY

INSTITUTE OF FUNDAMENTAL SCIENCES

It has been a quiet semester for our group at Massey, Palmerston North, with a couple of notable exceptions. In October, we thoroughly enjoyed the visit of Maclaurin lecturer Ken Ono. On November 14, a number of our group attended another very successful Wellington-Manawatu Applied Mathematics (WMAM) meeting, hosted by Victoria University.

Congratulations to Yuancheng Wang, who has successfully defended his thesis "Microbial co-existence and stable equilibria in a mechanistic model of enteric methane production", under the supervision of Tammy Lynch and Bruce van Brunt from IFS, and Peter Janssen and David Pacheco from AgResearch.

Howida Al Fran passed her PhD oral examination without emendations in August. Her thesis title was *The edge slide graph of the n-dimensional cube*, and her supervisors were Christopher Tuffley (main supervisor) and David Simpson. Howida is now home in Saudi Arabia.

Richard Brown

INSTITUTE OF NATURAL AND MATHEMATICAL SCIENCES

Alona Ben-Tal was appointed Deputy Head of the Institute of Natural and Mathematical Sciences in April, and *Gaven Martin* is once again Head of the New Zealand Institute for Advanced Study.

Carlo Laing and *Mick Roberts* were successful in the 2017 Marsden funding round. Carlo received $670,000 for the project "Function from structure: accurate reduced models of neuronal networks", and Mick received $415,000 for the project "Biodiversity and the ecology of emerging infectious diseases".

Gaven Martin and *Shaun Cooper* have each authored books. Gaven's book, An Introduction to the Theory of Higher-dimensional Quasiconformal Mappings, published by the American Mathematical Society, was started by his co-authors, the late Professor Frederick Gehring and Professor Bruce Bruce Palka from the United States' National Science Foundation.

Gaven finished the book following the death of Professor Gehring in 2012, who had been his PhD supervisor at the University of Michigan. The book offers a modern, up-to-date introduction to quasiconformal mappings from an explicitly geometric perspective. It emphasises both the extensive developments in mapping theory during the past few decades and the remarkable applications of geometric function theory to other fields, including dynamical systems, Kleinian groups, geometric topology, differential geometry, and geometric group theory.

Shaun's book, Ramanujan's Theta Functions, published by Springer, grew out of lectures given at Massey University since 2001. It provides an introduction and overview of Ramanujan's work on theta functions, and points to extensions to stimulate further research. The first half of the book shows how Ramanujan's results on theta functions can be organized in a systematic way and classified by level and weight. The second half of the book is on recent research and it is the first time that many of the topics have appeared in book form.

Gaven Martin joined other science leaders from around the world to discuss the social and economic relevance, influence and responsibilities of science at the World Science Forum 2017 in Jordan. Gaven was involved due to his work with the International Council of Science, a major sponsor of the World Science Forum. He took part in a two-day meeting of the Committee for Freedom and Responsibility in the conduct of Science, discussing the recent merger of International Council of Science with the International Social Sciences Council and the treatment of scientists in Iran and Turkey. The forum was opened by Jordan's Prince El Hassan bin Talal, who also presented the plenary session on the topic of 'Science for Peace'. Other speakers included the Prince's daughter, Princess Sumaya bint El Hassan, President of Hungary János Áder and South Africa's Minister for Science and Technology Grace Naeldi Pandor.

In July *Alona Ben-Tal* attended the SIAM annual meeting in Pittsburgh, USA, where she presented a poster, co-authored with Dr Emily Harvey, entitled: "Nonlinear Phenomena in a Piecewise Linear Model of Airflow in Birds' Lungs". During the conference she attended an inspiring panel discussion about the work of African-American women mathematicians that featured Christine Darden — one of the human computers included in the book "Hidden Figures" by Margot Lee Shetterly as well as three younger African-American women mathematicians. In August Alona attended the International Union of Physiological Sciences (IUPS) meeting in Rio De Janeiro, Brazil where she co-chaired a session entitled: "Cardiorespiratory interactions—from animals to humans". She also presented a talk at this session entitled: "Mathematical modelling of the cardiorespiratory system for the study of respiratory sinus arrhythmia (RSA)". The IUPS conference takes place every four years and only a fraction of attendees get to talk: this year it was 20% of around 1500 scientists who attended the conference.

In September *Mick Roberts* gave a VicANZIAM seminar at Melbourne University titled "How mathematical epidemiology became a field of biology".

Alona Ben-Tal, Winston Sweatman, Graeme Wake and PhD students *Valerie Chopovda* and *Faheem Zaidi* all presented contributed papers at the Thirteenth ANZIAM Engineering Mathematics and Applications Conference (EMAC) at the University of Auckland at the end of November. Alona spoke on Nasal Physiology modelling, Winston on Pollution Transport and Graeme on combating Red Needle Cast pine tree disease for the NZ Timber Industry. Faheem received an honourable mention for his talk. This is the first time the conference has been held outside of Australia, and the local organisers are from the Department of Engineering Science at the University of Auckland.

Visitors

The 2017 Maclaurin Lecturer Professor Ken Ono visited the campus on Tuesday October 10 and delivered a public lecture "Gems of Ramanujan and their lasting impact on mathematics". Ono was associate producer and mathematical consultant for the movie "The Man Who Knew Infinity", based on Ramanujan's biography written by Robert Kanigel. He showed clips from the movie and held the audience spellbound with inspiring and first-hand discussions preceding and following each clip. The lecture was followed with a reception and a free screening of the movie.

Shaun Cooper

VICTORIA UNIVERSITY OF WELLINGTON

SCHOOL OF MATHEMATICS AND STATISTICS

Rod Downey has been invited to give the 2018 Gödel Lecture at Logic Colloquium 18 in Udine, Italy. The lectureship is the premier talk at the annual European meeting of the Association of Symbolic Logic. This honour was announced at the end of a big year for Rod, which started with a symposium in his honour, held at Raumati, north of Wellington. This was organised impeccably by Adam Day and Noam Greenberg. One result of that was the volume *Computability and Complexity: Essays Dedicated to Rodney G. Downey on the Occasion of His 60th Birthday*, by the Springer Lecture Notes in Computer Science series. Computabilists from around the world then raced to Napier for the NZMRI Summer School, also organised by Adam and Noam. As reported in the last volume, Rod has also

been awarded a Humboldt Fellowship and the Shoenfield Book Prize. More recently, in August-September a month-long symposium on *Aspects of Computation* was also held in Rods honour at the National University of Singapore. The symposium featured sections on several aspects of Rod's research: parametric complexity, algorithmic randomness, classical computability theory, computable structures and reverse mathematics.

Lisa Clark has been travelling overseas, attending the Oberwolfach mini-workshop on *MASAs and Automorphisms of C*-Algebras* in September and, following the award of a Simons Visiting Professorship, on to visit the University of Southern Denmark in Odense to work with colleagues there. In early December, Lisa is also a speaker at the *Facets of Irreversibility: Inverse Semigroups, Groupoids, and Operator Algebras* conference at the University of Oslo. Meanwhile, Astrid an Huef and Iain Raeburn have been travelling in Canada and Australia while on research and study leave.

The recent announcements of funded Marsden grants included Noam Greenberg's project *Uncountable structures and effective properties*. This was appropriate recognition of the ground-breaking research Noam has been pursuing. Adding to that, we are delighted to recognise Noam's Fellowship of the Royal Society Te Apārangi. Noam has also been rejoined for a couple of months by post-doctoral fellow Rutger Kuyper.

It will be exciting for the School to welcome Professor Stephen Marsland to our whānau in January. Stephen has an outstanding reputation for his research across mathematics, computer science and data science/machine learning. This too has been recognised by his Marsden grants as PI *AviaNZ: Making Sure New Zealand Birds Are Heard* with Isabel Castro at Massey, Manawatu and as AI on Rachel Fewster's project *Cells and Whistles*. Stephen will also be a mentor for Miao Qiao's fast start project at Massey, Manawatu.

Richard Arnold has been making inroads in the pub talking-heads scene around Wellington recently as part of the RSNZ 'Ideas on Tap' session at the Rogue & Vagabond pub on *Why statistics is frustrating*, NerdNite's 'Let's get Political' session at the Meow bar on *What can go wrong with polls and referenda*, and he capped off as election night forecast statistician for TV1. Your correspondent addressed the university's Hunter Club for retired staff members on work with undertaken Marco Sonzogni in Translation Studies, Sydney Shep of Waiteata Press and Alexander Heyes which takes the form of a timeline of 'mathematics and poetry'.

Estate Khmaladze has been in Europe where he gave invited talks in Düsseldorf, Karlsruhe and Warsaw, the last on Statistics and Languages. This was followed by a plenary talk at the International Conferences of Georgian Mathematical Union, based on his joint paper with Wolfgang Weil concerning set-differentiation and statistics. Mark McGuinness was invited to the local Rotary Club's Breakfast series to talk about what drives him as a researcher in applied mathematics at Victoria. Mark has recently been elevated to convener of the Mathematics in Industry (MINZ) reference group, inheriting the mantle from Graeme Wake. Mark's huge experience in the MISG community worldwide will stand him in good stead. Matt Visser has also been around the world a few times, spending periods in Spain, Lisbon, Trieste and UK.

Happily, there were many successes in this year's academic promotion round. BD Kim, Dimitrios Mitsotakis, Richard Arnold, Ivy Liu, Rod Downey, Matt Visser, Mark McGuinness and Noam Greenberg all thoroughly earned their promotions. Steven Archer, one of our senior tutors, has been awarded the university's inaugural Te Rautaki Maruako Tutor Excellence Award for the Faculty of Science. This is welcome recognition of the incredible work Steve does on many fronts — helping and advising students, administering the SLP pool of markers and tutors, teaching and tutoring across several of our first-year courses, advising colleagues in the School and the Faculty about entrance standards, assisting the school office administration and much more.

Our postgraduate students are just returning to Wellington, having organised and participated in another successful New Zealand Maths and Stats Postgraduate Conference, held this year in beautiful Kaiteriteri. The committee included Susan Jowett, Emma Greenbank, Jessica Santiago and Sebastian Schuster, ably helped by Kelsey Firmin in the school office, while Dillon Mayhew, Monique Ladds and Mark McGuinness all contributed as plenary speakers.

Visitors and seminars. Dr Young Hong (Wolfson Brain Imaging Centre, University of Cambridge): Kinetic modelling in Positron Emission Tomography (PET); Professor Stephen Marsland (Massey University): The geometry and data analysis of shape; Kylie Reiri (Social Investment Agency): Combining statistics and data science: Reducing the time to insight for New Zealand's most challenging questions; Professor Ken Ono (Maclaurin lecturer, Emory University): Polya's Program for the Riemann Hypothesis; Professor Song-Ping Zhu (University of Wollongong): Parisian options and their fair price; Dr Jean-Luc Bouchot (RWTH Aachen): Compressed sensing — novel results and applications; Dr Martino Lupini (Caltech): The complexity of the classification problem in ergodic theory; Professor Leon Sterling (Swinburne University): Promoting STEM education in schools; Dr Dan Turetsky (Notre Dame University): The difficulty of finding isomorphisms; Dr Melanie Roberts IBM Research, Melbourne): Enhancing household resilience to bushfires through the mathematical modelling of embers.

Peter Donelan

UNIVERSITY OF CANTERBURY

SCHOOL OF MATHEMATICS AND STATISTICS

Congratulations to *Brendan Creutz*, *Daniel Gerhard* and *Blair Robertson* on their promotions to Senior Lecturer and to *Miguel Moyers Gonzalez* on his promotion to Senior Lecturer above the bar.

Congratulations to *Jeanette McLeod* who has been elected President of the Combinatorial Mathematics Society of Australasia (CMSA) for 2018, and who has been appointed to an honorary senior lectureship at the Australian National University.

Congratulations to *Brendan Creutz*, *Charles Semple* and *Mike Steel* who were successful in their bids to the Marsden Fund.

Brendan's project "Brauer groups, degrees and rational points on algebraic varieties" is in collaboration with Bianca Viray from the University of Washington, Seattle. The project is motivated by the problem of understanding how the existence of rational solutions to a system of polynomial equations may be influenced by the geometric and arithmetic properties of the algebraic variety defined by that system. For many important classes of varieties it is conjectured that these properties are encoded in an object associated to the variety known as the Brauer group. However, a general understanding of this group and how this information can be extracted from it are lacking. The aim is to identify proper subgroups of the Brauer group that capture this information, thereby elucidating its effect on the existence of rational points on algebraic varieties. The outcomes of this research will have practical applications to solving of systems of polynomial equations algorithmically.

Charles and Mike, as co-Principal Investigators, in collaboration with Magnus Bordewich, Durham University, and Amaury Lambert, UPMC University of Paris, will apply in their project "The Combinatorics of Reticulate Evolution" mathematical models to the complex evolutionary tree of life, in order to understand how species evolve by combining and sharing genes, as well as branching away from each other. While Charles Darwin viewed evolution as a branching treelike process, which gave rise to all the diversity of life on earth it has been discovered more recently that non-treelike processes, such as hybridisation (combining the genes of two organisms) and lateral gene transfer (direct gene transfer from one organism to another, especially common in bacteria) also play a role in evolution. As a result, the simple notion of a tree is insufficient to understand the course of evolution. A major challenge in evolutionary biology is to unravel these complicated historical relationships.

The grant is to study the mathematics of evolutionary networks and to develop and apply new mathematical, statistical, and computational techniques to study evolutionary processes and the combinatorial properties of evolution under random processes of reticulation. The aim is to tease out the tangled ancestral relationships buried within genetic data and to explore how certain evolutionary processes behave, which will add to our understanding of how life on earth evolved. The focus of the project is on three key mathematical questions whose answers are central to understanding how reticulation in evolution may have obscured ancestral relationships in the past, based on what we can observe today, and the extent to which a tangled network can be viewed as having an underlying treelike structure.

In September the School welcomed Erskine Fellow Richard Law from the University of York in the UK. Richard is a regular visitor in the School and is hosted by *Michael Plank*. He taught some introductory multivariable calculus at 100 level and stochastic processes in biology at 400 level. Richard's research interests are broadly in ecology, evolution and mathematics. He has extended his visit to Christchurch until the new year in order to work with Michael Plank on size-spectrum models of marine ecosystems. Richard is also collaborating with Rachelle Binny of Manaaki Whenua on collective animal movement and William Godsoe and Rowan Sprague at the University of Lincoln on spatial models of wilding pine.

Abstracts of PhD theses

Erik Istre, University of Canterbury

Supervisors: Maarten McKubre-Jordens, Zach Weber (Otago), Hannes Diener

Date: October 2017

Title: **Normalized naive set theory.**

The broad goal of this thesis is the realization of a mathematically useful formal theory that contains a truth predicate, or as it's called in the literature, a "naive theory". To realize this goal, we explore the prospects for a naive set theory which can define a truth predicate. We first consider some of the promising developments in naive set theories using various non-classical logics that have come before. We look at two classes of non-classical logics: weak relevant logics and light linear logics. Both of these have been used in the development of naive set theories. We review the naive set theories using these logics then discuss the strengths and weaknesses of these approaches.

We then turn to the primary contribution of this thesis: the development of a robust naive set theory by accepting only normalized proofs, an idea first proposed

by logician Dag Prawitz. It is demonstrated that this theory meets our need of logical strength in a system, while possessing more expressiveness in a foundational system than has come before. All of Heyting Arithmetic is recovered in this theory using a type-theoretic translation of the proof theory and other unique features of the theory are discussed and explored. It is further asserted that this theory is in fact the best case scenario for realizing informal proof in a formal system.

Günter Steinke

UNIVERSITY OF OTAGO

DEPARTMENT OF MATHEMATICS AND STATISTICS

Our former PhD student *Vee-Liem Saw*, who completed his PhD in November (see below), has received the Karl Schwarzschild Price for the best contributed talk at the 3rd Karl Schwarzschild Meeting in Frankfurt, Germany. These meetings aim to foster the synergy and the collaboration among senior academics and forthcoming scientific leaders working on gravity and the gauge/gravity correspondence. Vee-Liem is the overall winner of the Student-Junior joint session. His talk was on mass loss due to gravitational waves in the presence of a positive cosmological constant.

Philippe LeFloch (Director of Research at CNRS, Paris) visited the department for three weeks through the University's William Evans Visiting Fellowship. Philippe is a world renowned expert on partial differential equations, in particular, on non-linear wave equations. He is also well-known for his contributions to mathematical relativity, and he has been collaborating with *Florian Beyer* from the Otago Relativity Group for several years. In his public lecture "Waves around us. An applied mathematician's perspective" Philippe illustrated the role of mathematics in overcoming practical problems, and in a joint seminar with the Department of Physics he discussed the nonlinear stability of Minkowski spacetime.

A second William Evans Fellow in the department was Alan Gelfand (Duke University, USA), who is one of the most accomplished and influential contemporary statisticians. Alan has authored more than 280 scholarly articles and is considered a leading expert in Bayesian computation and spatial statistics. He gave the seminar "Scalable Gaussian process models for analyzing large spatial and spatio-temporal datasets", and he presented a two-day short course.

Abstracts of PhD theses

Daniel Willem van Wyk, University of Otago

Supervisors: Astrid an Huef and Lisa Orloff Clark

Date: 2017

Title: **The structure of GCR and CCR groupoid C*-algebras**

We remove the assumptions of amenability in two theorems of Clark about C*-algebras of locally compact groupoids. The first result is that if the groupoid C*-algebra is GCR, or equivalently then the groupoid's orbits are locally closed. We prove the contrapositive. We begin by constructing a direct integral representation of the groupoid C*-algebra with respect to a measure on the groupoid's unit space. If the orbits are not locally closed, then there is a non-trivial ergodic measure on the unit space. We adapt a known result for transformation groups to groupoids, which shows that the direct integral representation cannot be type I if the measure on the unit space is non-trivially ergodic.

The second result is that if the groupoid C*-algebra is CCR, then the groupoid's orbits are closed. Here we show that if a representation of a stability subgroup is induced to a representation of the groupoid C*-algebra, then the induced representation is equivalent to a representation as multiplication operators acting on a vector-valued L2-space. If we assume the groupoid C*-algebra is CCR, but an orbit is not closed, then the equivalence of two representations as multiplication operators leads to a contradiction.

Vee-Liem Saw, University of Otago

Supervisors: Jörg Frauendiener and Jörg Hennig

Date: 2017

Title: **Mass loss due to gravitational waves with a cosmological constant**

The theoretical basis for the energy carried away by gravitational waves that an isolated gravitating system emits was first formulated by Hermann Bondi during the 1960s. Recent findings from looking at distant supernovae reveal that the rate of expansion of our Universe is accelerating, which may be well-explained by including a positive cosmological constant into the Einstein field equations for general relativity. By solving the Newman-Penrose equations (which are equivalent to the Einstein field equations), we generalise this notion of Bondi mass-energy and thereby provide a firm theoretical description of how an isolated gravitating system loses energy as it radiates gravitational waves in a Universe that expands at an accelerated rate.

Jörg Hennig

OBITUARIES

Chang Chao Ping, 1923–2017

Chang Chao Ping was a Senior Lecturer in the Department of Mathematics for the years 1967 to 1983. He was born at Macau in 1923, he graduated PhD from the University of Chicago in 1964 and took up his position in Auckland in February 1967. In 1968 he told me that, in his early years in southern China, he much enjoyed a local fruit which was not sold commercially. For many years after that he never saw his favourite fruit until he arrived in Auckland, where he was delighted to see that "Chinese gooseberries" were the cheapest and most abundant fruit on sale.

Chao Ping was a specialist in Analysis and he was noted, in the Auckland part of his career, through his setting up and teaching the main second-year Calculus course. This course was a model of good design and good teaching style, with appropriate and realistic aims and excellent outcomes. His research publications include: On Bochner–Riesz summability almost everywhere of multiple Fourier series, *Studia Math*. **26** 1965 25-66 **MR0185366**, On a condition for almost everywhere Bochner-Riesz summability of multiple Fourier series, *Studia Math*. **28** 1966/1967 145-154 **MR0216241**, and Mean value points of analytic functions of a complex variable, *Southeast Asian Bull. Math.* **3** (1979), no. 2, 100-115 **MR0564800**.

He was a kind and considerate colleague and a great friend to those of us who knew him during his years in the Department. Lynn Gilmore writes that "Dr Chang was my teacher and supervisor in my first teaching in the Department (Maths 2 in 1969) and I have always had great liking and respect for him". In 1981 I became very ill, and Chao Ping was the first of my colleagues to visit me in the Intensive Care Unit at Auckland Hospital. I much appreciated his kindness. Chang Chao Ping died on 2017 August 24, at the age of 94.

Garry J. Tee

REPORTS ON EVENTS

NZMS-AMS Maclaurin Lecturer 2017 — Ken Ono

The Maclaurin Lectureship was a reciprocal exchange between the New Zealand Mathematical Society and the American Mathematical Society. A New Zealand and a United States-based mathematician have toured each other's countries on alternate years between 2011 and 2017, with the lecturers chosen by both societies. Ken Ono was the 2017 NZMS/AMS Maclaurin Lecturer. Alas, it appears he is to be the last. The two societies are exploring alternative forms of collaboration.

Ono is a distinguished number theorist, working on the theory of modular forms. One of his best known results is on the partition function $p(n)$ which counts the number of ways of writing a positive integer n as a sum of positive integers, thus $p(4) = 5$ as $4 = 3+1 = 2+2 = 2+1+1 = 1+1+1+1$. The function $\sum p(n)e^{2\pi inz}$ is related to the Dedekind eta function, a modular form. The legendary Indian mathematician S. Ramanujan had found some remarkable divisibilities for the values of the partition function, for instance $p(5k+4)$ is always divisible by 5, and similar divisibilities hold modulo 7 and 11. After slow progress for eighty years, Ono, in a 2000 paper in the Annals, [3] found similar divisibilities modulo every prime, for example $p(59^4 \cdot 13k + 111247)$ is always divisible by 13. Ramanujan has played a major role in Ono's life and work.

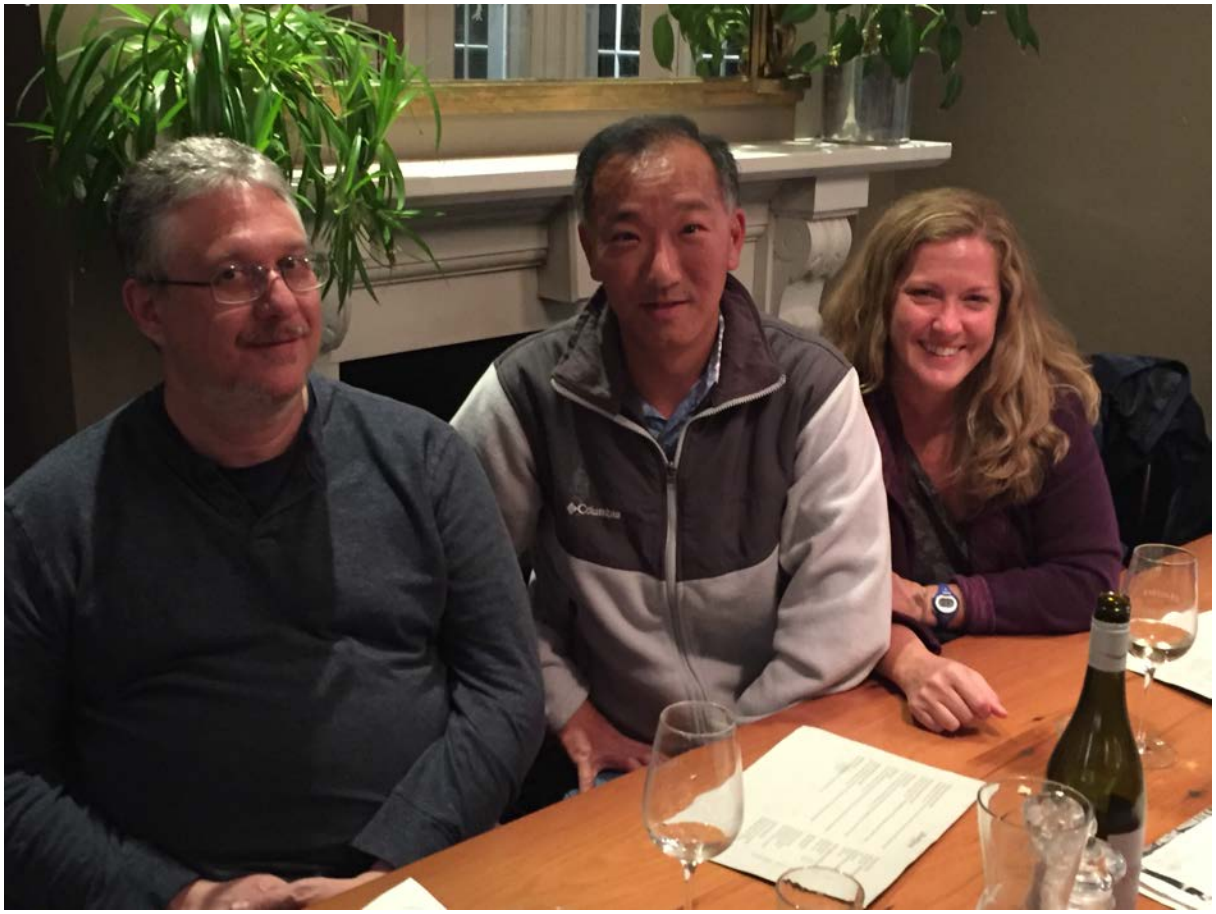


Figure 1: The author with Ken and Erika Ono.

Another important recent work of Ono and collaborators John Duncan, Michael Mertens extends the Monstrous Moonshine conjectures of Conway and Norton, linking the Monster finite simple group to modular forms, to other finite simple groups. Their work was published in Nature [1], quite unusual for pure mathematics, and has a nice write up in Quanta magazine [2]. Ono spoke about this work in a seminar talk at the University of Auckland. He is very excited about his recent work with Michael Griffin, Larry Rolen, and Don Zagier which opens a potential new attack on the Riemann hypothesis and spoke about it at various stops in his tour of New Zealand universities.

Ono has written a candid memoir [4] about his upbringing in the US as the son of a distinguished immigrant Japanese mathematician, his early interest in maths followed by teenage rebellion against his father's wishes that

he also became a mathematician, to finally reconciling with maths, finishing his PhD and eventual success as a mathematician. In all of that, the figure of Ramanujan appears prominently and you need to read the book to find out how.

Ono earned his PhD in 1993 at UCLA and he is currently the Asa Griggs Candler Professor of Mathematics at Emory University in Atlanta. He received various honours and awards, including the Presidential Career Award, the NSF Director's Distinguished Teaching Scholar Award, a Sloan Fellowship, a Packard Fellowship, and a Guggenheim Fellowship. He is a fellow of the American Math Society. He is also very well regarded as a mentor of mathematicians be it at undergraduate, postgraduate and postdoctoral levels.

Recently, because of his extensive knowledge of and connection with Ramanujan, he was a mathematical consultant for the movie, "The Man Who Knew Infinity" about Ramanujan's life. His experiences in this role formed the basis for his beautiful public lecture, "Gems of Ramanujan and their Lasting Impact on Mathematics", which he gave at every stop in his tour of New Zealand universities. The lecture at the University of Canterbury was extremely well attended with members of the University community and the general public with ages varying from 8 to 88 and something for everyone to enjoy from prime numbers to Jeremy Irons. The public lecture at Massey, Albany, was followed by a screening of the movie and both were extremely well received. One of the many comments sent to the organiser by attendees said "The audience was completely enraptured by the story and Ken's mastery of the subject." In Palmerston North, the public lecture was held at a local high school to a full capacity audience.

His trip to New Zealand, accompanied by his wife Erika, was not all work, though. It included a stopover in Fiji on the way to swim with sharks (without the protection of a cage!), a trip to Fiordland, which included diving and swimming with dolphins in Milford Sound and a competitive long distance run around Lake Taupo among others.

They were in New Zealand in October 2017, with the following stops: Christchurch, 1st–4th, Dunedin, 4th–6th, Auckland, 8th–11th , Hamilton, 11th–13th, Palmerston North 15th–17th and Wellington, 17th–19th.

List of past Maclaurin lecturers:

2012 Marston Conder, University of Auckland

2013 Terence Tao, University of California, Los Angeles

2014 James Sneyd, University of Auckland

2015 Ingrid Daubechies, Duke University

2016 Gaven Martin, Massey University

2017 Ken Ono, Emory University

Felipe Voloch (University of Canterbury)

References

[1] John F. R. Duncan, Michael H. Mertens, Ken Ono, *Pariah moonshine*, Nature Communications 8, Article number: 670 (2017) https://doi.org/10.1038/s41467-017-00660-y

[2] Erica Klarreich, *Moonshine Link Discovered for Pariah Symmetries*, https://www.quantamagazine.org/moonshine-link-discovered-for-pariah-symmetries-20170922/

[3] Ken Ono, *Distribution of the partition function modulo m*, Ann. of Math. 151 (1): 293–307 (2000). http://www.jstor.org/stable/121118

[4] Ken Ono with Amir Aczel, *My Search for Ramanujan: How I Learned to Count*, Springer 2016.

New Zealand Mathematics and Statistics Postgraduate Conference 2017 (NZMASP'17)

On the 26th of November 2017, 50 postgraduates, from universities all around the country, gathered in Kaiteriteri to attend the annual New Zealand Mathematics and Statistics Postgraduate Conference. NZMASP is a student-run conference designed to provide postgraduate students with an opportunity to practice presenting their research and to meet other postgraduates from all around New Zealand. Each year the conference is hosted by a different university, this year it was hosted by Victoria University of Wellington and we are pleased to announce that 2018 will be organised by Massey University Palmerston North.

As usual the talks given at NZMASP'17 were well presented and focusing on a wide range of topics. This year there were 13 pure, 17 applied and 14 statistics talks with topics ranging from peculiar entanglement in time effects, to matroid theory and the inner workings of deep learning. In addition to the student talks we were delighted to have 4 plenary speakers: Dr Marc Droske from Weta Digital and Dr Monique Ladds, Dr Dillon Mayhew and Prof Mark McGuinness, all from Victoria University. We would like to thank them for attending and sharing their expertise with us.

We would also like to congratulate this year's prize winners: Sarah Mark for the best pure talk (which she also won in 2016), Vee-Liem Saw for the best applied talk and Nick Jin Sean Lim for the best statistics and overall talk.

This conference would not have been possible without the generous support from our sponsors: The New Zealand Mathematics Society (NZMS), the New Zealand Institute for Advanced Study (NZIAS), Statistics New Zealand, the Australian New Zealand Institute for Applied Mathematics (ANZIAM), Plant and Food Research, Weta Digital, MathWorks and all the participating universities.

The NZMASP'17 Organising Committee:
Susan Jowett
Sebastian Schuster
Emma Greenbank
Meenu Jose
Jessica Santiago
Del Rajan
William Critchlow
Seyedvahid Amirinezhad
Andrew Probert
Jasmine Hall

Cleveland; the meeting point of Mathematics, Computer Science, and Engineering

The International Design Engineering Technical Conferences & Computers and Information in Engineering Conference (IDETC/CIE) running annually by American Society of Mechanical Eng inners (ASME) is a interdisciplinary gathering event where all researchers and professionals working on mechanical engineering problems meet together. This year, it was in Cleveland, Ohio.

In this conference, I presented the core part of our current research and indeed my thesis. In this work, we studied the impact of design parameters on the singularities of mechanism. This phenomenon occurs as long as the configuration space, which represents all feasible configurations for the given mechanism, *transversally intersect* the singular set, which includes all configurations where Jacobian matrix is rank deficient. Therefore, the Transversality theory form differential geometry is a crucial tool to study and understand this problem.

I could get some good feedbacks after my talk. For example, Prof. Ting from Tennessee Technical University was interested in my research so we had a couple conversations during the conference about the connection between what we proposed as Generalised Grashof conditions and what he had already proposed as the rotatability laws. Moreover, I met Prof. Chirikjian from Johns Hopkins University. He is one of the great mathematician working on different problems related to mathematics including Theoretical Kinematics. Our chat regarding statistical mechanics and parts entropy was very informative for me.

Hamed Amirinezhad (Victoria University of Wellington)

41st Annual Conference of the International Group for the Psychology of Mathematics Education (PME 41)

The 41st Annual Conference of the International Group for the Psychology of Mathematics Education (PME 41) was held in Singapore from July 17–22, 2017. I was awarded the 2017 Gloria Olive Student Travel Award by the New Zealand Mathematical Society, and was therefore able to attend PME 41.

It was my first international conference, and it was a privilege and a remarkable experience. The paper I submitted for the conference was about how a group of mathematics students were persistently attached to an incorrect mathematical solution as they worked on a one-hour long task in graph theory. The paper examined the students' structures of attention to explain the persistence of the students' incorrect solution, and provided some (sympathetic) insight into the struggle that takes place when students try to adapt their existing mathematical knowledge to cope with new situations. More generally, the paper examined the *students' problematic mathematical knowledge* from a single existing methodological stance leading to particular insights on this important phenomenon. The paper has been included in the official conference proceedings.

The forty-minute presentation I gave at the conference was a great experience. I decided to present something a little different from what I had written in the submitted paper. This decision, of course, led to some critical (but nonetheless constructive) feedback. I still presented on the same piece of data, but from a different theoretical perspective (i.e., the emergence of prototypical examples in students' mathematical thinking as opposed to their structures of attention). My audience consisted of about thirty to forty mathematics education researchers from different countries, who gave me very constructive and supportive feedback (including several challenging questions!). The feedback I received pushed me towards new lines of thinking, and helped me develop a manuscript that I plan to submit, in the near future, as a journal article.

Because PME is one of the biggest and most prestigious research conferences in mathematics education, I had the opportunity to meet and speak with various leading researchers in the field about my research. Furthermore, I was accepted to attend an "Early Researchers Day" that consisted of sixty people who, like myself, are at the early stages of their research careers. This gave the opportunity to interact with other PhD students, Postdoctoral Fellows and other "early researchers". I hope to be able to collaborate with some of them in future. I thank the New Zealand Mathematical Society for making this remarkable experience possible!

John Moala (University of Auckland)

SDSM-2017 Summer School and CELMEC VII

I had the good fortune to attend the Satellite Dynamics and Space Missions (SDSM-2017) Summer School and the Celestial Mechanics (CELMEC VII) conference in two successive weeks from August 27 to September 9.

The CELMEC conference runs every four years. The participants of the conference include mathematicians, physisists, astrophysisists. The conference addresses a range of topics both theoretical and practical, such as computation of real orbits of Solar System objects and those for space missions, dynamics of the n-body problem, tidal evolution of bodies.

The SDSM Summer School runs every three years, however, it has not been running for about last ten years. I find myself very lucky to happen to attend both events.

During the summer school I presented a talk on the "Planar periodic orbits arising from the Schubart-like periodic orbit in the Caledonian four-body problem" and at the conference I presented a poster on the "A family of periodic orbits in the Caledonian symmetric four-body problem". That was my first experience of showing my research to an audience specialised in celestial mechanics, and I really appreciate the feedback I have been given.

The events I attended in Italy played an important role in my PhD. I have met people whose papers I have been reading throughout my research. I would like to highlight my meeting with Bonnie Steves from Glasgow Caledonian University in Scotland. She introduced the Caledonian four-body problem I am studying in my PhD. That was really valuable for me to explain my research questions to her and try to relate my solutions to her research.

Another valuable experience was a workshop organised by the Summer School Organising Committee which included a one minute version of a "three-minute thesis". We had just one evening to prepare our slide with a one minute presentation, and then we presented our works and received feedback from the organising committee.

I am grateful to the New Zealand Mathematical Society through their Gloria Olive Award for their financial support for my participation in the SDSM-2017 Summer School and the CELMEC VII conference.

Valerie Chopovda (Massey University, Auckland)

SIAM Conference on Applications of Dynamical Systems

I would like to take this opportunity to thank the New Zealand Mathematics Society for assistance towards my attendance of the SIAM Conference on Applications of Dynamical Systems held in Utah, USA, in 21–25 May this year. This is the major conference in of Dynamical Systems, attracting attendance by members of its international community.

I was invited to present my work regarding the computation and geometry of isochrons of saddle-type periodic orbits form of my talk, "Isochrons for Saddle-Type Periodic Orbits in Three-Dimensional Space" in the "Isochrons and Isostables" mini-symposium organised by Jeoff Moehlis (University of California) and Dan D. Wilson (University of Pittsburgh). This talk was well received, leading to follow up conversations with interested audience members. The symposium also allowed me the opportunity to see applications of isochrons for control, and consider the implications of phase in stochastic systems.

Conversation with Harry Dankowicz (University of Illinois) lead to the implementation of an isochron computation in the MATLAB based numerical continuation program 'CoCo', and on going collaboration to refine and construct a user accessible toolbox for isochron computation in CoCo. This conference was a great opportunity for networking and seeing the wider applications and research going on in Dynamical Systems research on the international stage.

James Hannam (The University of Auckland)

Computational Dynamics workshop at the conference Foundations of Computational Mathematics

I would like to thank the NZMS for providing me with a childcare support grant to participate in the workshop *Computational Dynamics* that was held during the conference *Foundations of Computational Mathematics*

in Barcelona on 13-15 July. In this workshop I gave an invited talk on "The geometry of blenders in a three-dimensional Hénon-like family".

Since I was still breastfeeding my 18 months old daughter at the time, I would not have been able to participate in this workshop without taking her and my husband as her carer along with me.

In my current research project I study a new and complicated type of invariant object called a blender. A blender is an invariant set that is so "dense" that it acts geometrically as a set of higher dimension. This abstract phenomenon can be used to construct higher-dimensional chaos (so-called robust non-uniform hyperbolicity) in dynamical systems. Together with Bernd Krauskopf, Hinke Osinga and Katsutoshi Shinohara, I am studying an explicit example of a three-dimensional Hénon-like map that is proved to exhibit a blender at a specific point in parameter space. As a result of our collaboration, I generated the first numerical pictures of the geometry of a blender and developed numerical methods to provide evidence for the existence or non-existence of blenders at different parameter values.

Participating in the workshop *Computational Dynamics* was an excellent opportunity for me to take our results on the numerical evidence for the existence of blenders to the experts in computational methods in dynamical systems. More specifically, this workshop was organised by Ángel Jorba (Universitat de Barcelona), Hiroshi Kokubu (Kyoto University) and Warwick Tucker (Uppsala University), who are experts on computations of invariant objects and on computer-assisted proofs in dynamical systems. I discussed with them and other experts in the field our numerical results on the geometry and appearance of blenders and, in particular, the possibility of extending our numerical methods towards providing computer-assisted proofs for the existence or non-existence of blenders in different parameter regimes in this and in other systems. Overall, participating in this workshop helped me to finish the first part of this ongoing project, which enabled me and my collaborators to write up our results as a manuscript that we submitted for publication in November.

Stefanie Hittmeyer (University of Auckland)

Report on the 5th Heidelberg Laureate Forum

I was nominated by the New Zealand Mathematical Society to participate in the 5th Heidelberg Laureate Forum (HLF) which took place in September, 2017. The forum brings laureates of some of the most prestigious awards in mathematics and computer science together with 200 young researchers, 100 of each discipline, from all over the world. The forum combines general talks by the laureates on a range of topics with informal group discussions and substantial time to interact with the laureates. One of the main objectives of the forum is to allow the interaction between the laureates and the young researchers, for example in shared lunches and dinners. Needles to say, the organisation was perfect and top class.

Attending HLF was a great and very enjoyable experience. The talks by the laureates introduced me to some mind-blowing projects that are taken place in academia, which are not what one encounters every day. For some of these revolutionary projects, as they still emerge, it is very interesting to see how early-stage science is being made. I spoke with some of the laureates and was very surprised to see the passion that they have to speak with young researchers and try to learn and get some ideas from them. This has been a unique experience, and I thank NZMS for nominating me.

Barak Shani (University of Auckland)

GENERAL NOTICES

Call for applicants to attend the 6th Heidelberg Laureate Forum

The 6th Heidelberg Laureate Forum (HLF) will take place in Heidelberg, Germany during September 23–28, 2018.

At HLF all winners of the Fields Medal, the Abel Prize, the ACM A.M. Turing Award, the Nevanlinna Prize, and the ACM Prize in Computing are invited to attend. In addition, young and talented computer scientists and mathematicians are invited to apply for participation. The previous HLFs have been an exceptional success. The HLF serves as a great platform for interaction between the masters in the fields of mathematics and computer science and young talents. The HLF was initiated by the late German entrepreneur Klaus Tschira, and is supported by the Klaus Tschira Foundation, The Norwegian Academy of Science and Letters, The Association for Computing Machinery, as well as The International Mathematical Union.

Applications for participation at the 6th HLF are open in three categories: Undergraduates, PhD Candidates, and PostDocs. See the webpage www.application.heidelberg-laureate-forum.org for the online application and further information. The NZMS can nominate young researchers to attend the Forum. Nominated persons get "priority treatment", but, since there may be too many nominations, they have no acceptance guarantee. The deadline for applications is February 9, 2018. If you wish to be nominated by the NZMS email Vivien Kirk v.kirk@auckland.ac.nz by February 1st, 2018.

A PhD student from New Zealand attended the 5th HLF in September 2017; you can read a report on the experience on page 33.

Vivien Kirk

Tight Frames and Approximation Conference

The New Zealand approximation theory group is pleased to announce its fourth meeting:

> Tight frames and Approximation
> 20–23 February 2018
> Taipa, Doubtless Bay, New Zealand

The topic "Tight frames and Approximation" will be interpreted broadly. We plan to allocate lots of time without lectures for informal interactions, including the following working groups:

> Zauner's conjecture (Shayne Waldron)
> Pluripotential theory and algebraic geometry (Sione Ma'u)
> Radial basis functions (Rick Beatson)

Further information, including registration fees, is at math.auckland.ac.nz/Conferences/NZATG-2-2018/.

The organisers Rick Beatson, Sione M'au, and Shayne Waldron

Auckland Numerical Ordinary Differential Equations 2018

ANODE 2018

19 – 23 February 2018

The ANODE 2018 Conference will be held as follows:

Venue: Heritage Hotel, Auckland, New Zealand

Dates: 19 – 23 February 2018

Topics include:

Analysis of numerical methods
Geometric integration
Functional differential equations
Stochastic differential equations
Applications
Numerical software

Organising committee:

Saghir Ahmad (sahm056@aucklanduni.ac.nz)
John Butcher (butcher@math.auckland.ac.nz)
Gulshad Imran (ggul005@aucklanduni.ac.nz)
Nicolette Rattenbury (nicolette.rattenbury@auckland.ac.nz)
Shixiao Wang (wang@math.auckland.ac.nz)

Website: https://anode2018.wixsite.com/anode2018home

Enquiries: John Butcher

Likely participants include:
Saghir Ahmad, Julien Alexandre dit Sandretto, Igor Boglaev, Luigi Brugnano, Kevin Burrage, John Butcher, Elena Celledoni. Rob Corless, Angel Durán, Wayne Enright, Yonglei Fang, Jing Gao, Annie Gorgey, Yang He, Gulshad Imran, James Jackaman, Zdzislaw Jackiewicz, Stefan Kopecz, Huaning Liu, Robert McLachlan, Volker Mehrmann, Paul Muir, Andreas Naumann, Hiroshi Ohno, Brynjulf Owren, Helmut Podhaisky, Nicolette Rattenbury, Chus Sanz-Serna, Philip Sharp, Wei Shi, Tim Steinhoff, Lina Song, Yajuan Sun, Yifa Tang, Benjamin Tapley, Hongjiong Tian, Jim Verner, Shanshan Wang, Shixiao Wang, Joerg Wensch, Xinyuan Wu, Hongli Yang, Changying Ying, Xiong You, Xianyang Zeng, Beibei Zhu

Previous Challenges have come from:

SANFORD

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We look forward to seeing you there.

See more: www.minz.org.nz

NZMS NOTICES

The NZMS Education Group is Working Towards a Vision of NZ Mathematics for the 21st Century

The New Zealand Mathematics community (educators, researcher, and employers) needs to address changes to teaching, learning, and use of mathematics. In 2018 the government has a planned review of NCEA and this will be followed by future assessment and curriculum reviews. The NZMS Education Group is launching an effort towards creating a vision of 21st century mathematics for NZ schools. We are currently focussing on the secondary sector. However, past, recent, and future changes in this area affect universities and employers as well.

Some questions we are considering:

1. What are the purposes of school mathematics education?
2. How can we promote an equitable common mathematics pathway?
3. What are the essential mathematical concepts and habits of mind that all high school students should learn and understand at a deep level?
4. How should changes in technology be reflected in secondary school mathematics?

We would invite you to join us in exploring these questions.

Background

As you may know there has been a paradigm shift in Statistics education in NZ moving towards a more conceptual understanding of statistical thinking. This is consistent with the broader goals of the NZ Curriculum (NZC) (Ministry of Education, 2007).

Compared with the contemporary approach developed through the Statistics achievement objectives, Mathematics remains more traditional. (RAMP report on Mathematics and Statistics, 2015).

Here is some background information on each of the four questions to help frame your understanding of the current NZ context.

1. What are the purposes of secondary school mathematics education in NZ?

The NZ Ministry of Education Senior Secondary Guides gives this rationale:

> 1. *Inspire thinking.* Mathematics and statistics make sense of information, experience, and ideas by engaging students to think:
>   - flexibly and creatively
>   - critically and effectively
>   - strategically and logically.
> 2. *Stimulate creativity and curiosity.* Mathematics and statistics open the door to a world of beauty, mystery, and awe. They provide students with the enjoyment of intellectual challenge: opportunities to explore ideas and to wrestle with interesting problems. Mathematics and statistics provide ways of connecting abstract ideas with real world thinking.
> 3. *Equip students for the 21st century.* Mathematics and statistics equip students with the knowledge and skills to be global citizens in the 21st century. Effective citizens have the ability and inclination to use mathematics and statistics at home, at work, and in the community by:
>   - using problem-solving strategies
>   - using mathematical and statistical models to solve problems
>   - making sensible estimates
>   - using and interpreting data
>   - evaluating mathematical and statistical information
>   - communicating ideas.

What do you think the purpose of school maths should be? Do you agree with NZ Ministry of Education? Do you think anything is being left out?

2. How can we promote an equitable common mathematics pathway?

Mathematics has often been treated as an elite pathway. How often do you hear people say 'I could never do maths'? It is a pathway that blocks off choices for students; it blocks possibilities. We cannot continue creating a mathematical 1% while the rest of society doesn't understand what we do or why we do what we do.

"Tracking students into qualitatively different course progressions, where some students have access to mathematics instruction that prepares them for postsecondary education opportunities while others do not, reinforces the misguided notion that only some people — stereotypically, middle-class and white students — are capable of achieving in mathematics." (Boaler, 2011)

In 2016, OECD reported that more than 70% of students attend schools where the Principal reports that students are grouped by "ability;; for mathematics instruction. Streaming students into qualitatively different pathways severely limits and, all too often ends, students' opportunities in mathematics and STEM careers. It is also the consensus of the NZMS education group that streaming is harmful to students.

Su (2017) "Student and teacher tracking practices must be dismantled if we are to achieve the goal of supporting each and every student in reaching his or her potential in mathematics."

Bressoud (2015) recommended against racing to calculus and suggested instead providing "an alternative to calculus in high school that focuses on strengthening students' understanding of algebra, geometry, trigonometry, and functional relations while building problem solving skills."

What do you think Mathematics for all students looks like? How have the Numeracy Standards helped or hindered this? How have the University Entrance Numeracy levels helped or hindered this?

3. What are the essential mathematical concepts and habits of mind that all high school students should learn and understand at a deep level?

The NZ Curriculum gives the following *Learning area structure* to Maths and Stats.

> The achievement objectives are presented in three strands. It is important that students can see and make sense of the many connections within and across these strands.
>
> *Number and algebra* — Number involves calculating and estimating, using appropriate mental, written, or machine calculation methods in flexible ways. It also involves knowing when it is appropriate to use estimation and being able to discern whether results are reasonable. Algebra involves generalising and representing the patterns and relationships found in numbers, shapes, and measures.
>
> *Geometry and measurement* — Geometry involves recognising and using the properties and symmetries of shapes and describing position and movement. Measurement involves quantifying the attributes of objects, using appropriate units and instruments. It also involves predicting and calculating rates of change.
>
> *Statistics* involves identifying problems that can be explored by the use of appropriate data, designing investigations, collecting data, exploring and using patterns and relationships in data, solving problems, and communicating findings. Statistics also involves interpreting statistical information, evaluating data-based arguments, and dealing with uncertainty and variation.

In *Effective pedagogy in mathematics*, Anthony and Walshaw list habits of mind that should appear in a mathematics classroom. "Effective teachers set tasks that require students to make and test conjectures, pose problems, look for patterns, and explore alternative solution paths. Open-ended and modelling tasks, in particular, require students to interpret a context and then to make sense of the embedded mathematics." (pp. 13–14)

What is the essence of mathematics? What do you think *every* NZ student should know and be able to do?

4. How should changes in technology be reflected in high school mathematics?

Seeley (2016) suggested "as a result of advances in technology some mathematics is now more important, some mathematics less important . . . and some mathematics is possible for the first time."

Digital technology can serve three main functionalities (Drijvers, Boon, and Van Reeuwijk 2010):

1. a tool for doing mathematics and statistics,

2. a learning environment for fostering the development of conceptual understanding,

3. a learning environment for practising skills.

Mastery of skills should not be a prerequisite for using the technology in any content area, but instead the focus should be on understanding and interpreting the results (Roschelle et al. 2000).

How do you use technology in the mathematics you do? Students have easy access to Wolfram Alpha, how does this change the practice of mathematics?

To be involved

Sign up to be a member of the NZMS Education Group on the webpage, nzmathsoc.org.nz/?education. Through this you will receive our newsletters. On the webpage there are also links to some forums where people have been posting their thoughts on each of these questions. You can rate their responses and add your own.

Further Reading

The NCEA Review and Maintenance Programme (RAMP) report on Mathematics and Statistics (ncea.tki.org.nz/What-s-new/RAMP-literature-reports).

The US Nation Council of Teachers of Mathematics has recently put out a review on similar ideas. Google *NCTM Catalyzing Change* to download the pdf document.

Cami Sawyer and Rachel Passmore, on behalf of the NZMS education committee

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FYiMaths

First Year in Maths (FYiMaths) is a network of mathematicians teaching in universities across Australia and New Zealand. The network was established in Australia more than five years ago and this year we held two meetings of the New Zealand sub-group. The first of these meetings was held at the NZ Association of Mathematics Teachers (NZAMT) Conference in Christchurch during October, and the second was held during the Mathematics Education Day as part of the NZMS Colloquium in Auckland during December.

The goal of the group is to improve outcomes for students in undergraduate mathematics courses by sharing and developing teaching practices and building connections between secondary schools and universities. In our meetings we had presentations on innovative teaching of first year university students and had discussions exploring the issues faced by both students and teachers.

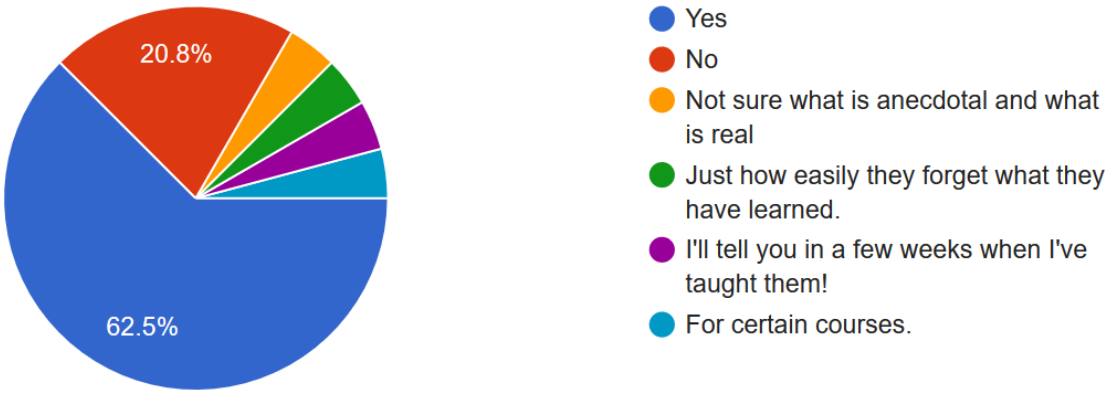
FYiMaths NZ is working as an interest sub-group of the NZMS Education Group. We are forming a community of tertiary and secondary mathematics educators. Through this group we will explore how to help students with the transition from secondary to tertiary and create improved learning experiences in university mathematics, as well as other relevant issues that arise.

To join the Australian parent organisation: fyimaths.org.au/members/membership/.

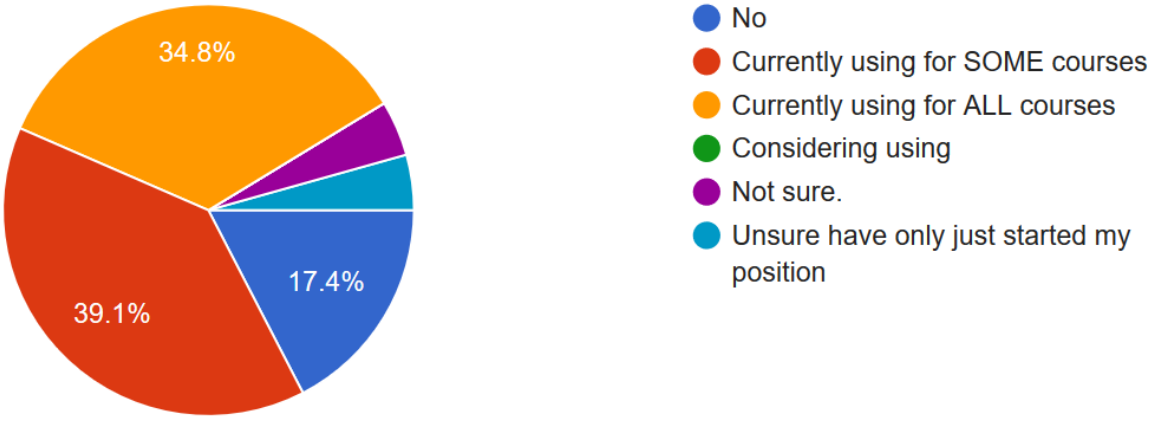
To be included on the NZ newsletter: nzmathsoc.org.nz/?education on the right hand side click mailing list and select FYiMaths.

In August, we sent the FYiMaths Survey to all NZ university maths staff. We had 24 responses. Here is some of what we learned.

1. Do you have issues with the preparedness of your students for FY maths courses?



2. Does your university use NCEA to determine the placement for FY maths courses?



3. Do you have any teaching issues, concerns, or interests that you want to discuss or share with other FY maths teachers?

   - Sharing of resources.
   - Possible (informal) standardisation of curricula.
   - Impact of enrolment trends in year 13 maths papers.

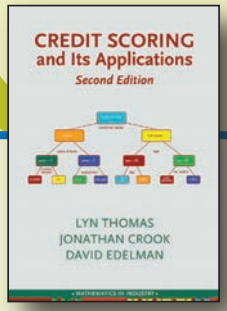
- The huge range of student backgrounds depending on their school.
- FY courses can have 2nd and 3rd year students as well as first year.
- Universities not appreciating the diversity of skills, under NCEA, that students now leave school with.
- How to identifying useful NCEA data.
- Finding online testing options that aren't multi-choice.
- Strategies for training student tutors.
- Best methods for contacting or engaging our current mathematics students.
- Techniques for improving pass rates.
- A lack of multiplicative, proportional, and algebraic reasoning by many students.

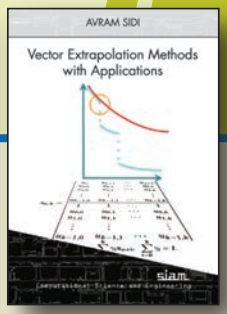
The FYiMaths Network in NZ has been established by Julia Novak and Cami Sawyer because they are interested in furthering conversations around teaching and learning. Julia is a professional teaching fellow at the University of Auckland and the Associate Dean (Teaching and Learning) for the Faculty of Science. Cami is a senior tutor at Massey University.

What are issues that you think FYiMaths should be considering? Become involved. Send Julia and Cami an email at fyimaths@math.auckland.ac.nz.

Julia Novak and Cami Sawyer

New & Notable Titles from SIAM





Credit Scoring and Its Applications, *Second Edition*

Lyn Thomas, Jonathan Crook, and David Edelman

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Recognized as the bible of credit scoring, this new edition of a long-time favorite contains a comprehensive review of the objectives, methods, and practical implementation of credit and behavioral scoring. New to the second edition are lessons that can be learned for operations research model building from the global financial crisis, current applications of scoring, discussions on the Basel Accords and their requirements for scoring, new methods for scorecard building and new expanded sections on ways of measuring scorecard performance.

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Avram Sidi

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Amir Beck

MOS-SIAM Series on Optimization 25

The primary goal of this book is to provide a self-contained, comprehensive study of the main first-order methods that are frequently used in solving large-scale problems. The author has gathered, reorganized, and synthesized (in a unified manner) many results that are currently scattered throughout the literature, many of which cannot be typically found in optimization books.

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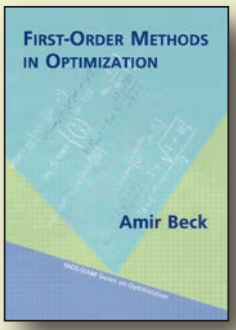

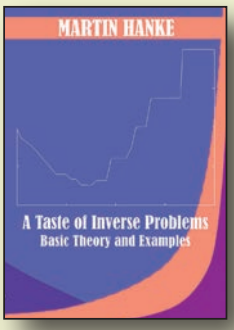

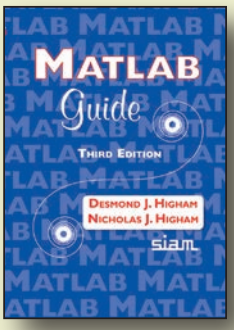

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