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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 Mark C. Wilson with paid proofreader assistance. 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 mcw@cs.auckland.ac.nz.

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EDITORIAL

Although a relatively static publication such as this is definitely useful, it is clear that the NZMS needs another method of disseminating information in real time, one which members can contribute to. For example, there are many interesting mathematical visitors to NZ, but often we don't find out about them until they have already left. I am interested in reader feedback about what kind of service NZMS could provide: an email list, Twitter account, . . . ?

This issue is rather thinner than usual, with less mathematical content. This should be rectified in the next issue. Local news is becoming less and less reliable. This is not the fault of the correspondents, who can mostly only pass on information provided by their colleagues. So, please let people know what you are up to.

Our Profile this issue is of David Wall, whom I am sure tried to teach me something about numerical solution of PDEs far too many years ago at Canterbury. The "Where Are They Now" feature is one that I hope will continue after my tenure as editor. I already have the following suggestions for subjects: Rowan Killip, Sikimeti Mau, Maurice Dodson, James Milne, David Benney. I welcome more suggestions, and also offers of brief interviews with the people concerned. For the next issue we plan an interview with Ingrid Daubechies. Ideas for other interviewees are welcome.

As always, I would like to see more correspondence. I believe that at least a few people do read this publication, and probably even have some opinions about items included in it. Please share them.

I have noticed that researchers seem to have less free time and to be less likely to spend time on activities that help their colleagues than in the past. For example, it is getting harder to convince people to contribute to this newsletter. Also, I am currently trying, as editor, to shepherd a paper through refereeing, and the first 5 people I asked to referee have refused. This is a new and unpleasant experience. If the mean publication rate per researcher is p papers per year, and we need r referee reports per paper, then on average we need to be refereeing for pr papers per year. Note that this is independent of the number of authors per paper (except that as that number grows, it is easier to publish and we can perhaps afford to spend relatively more time refereeing). I wonder whether the continued increase in expectations for p and the fact that r is (I think) now at least 2 for most journals means that the system will soon collapse under the strain.

One reason for this apparent selfishness may be that, in an increasingly competitive world where our performance is regularly measured, these socially desirable activities "don't count". So anything that removes that excuse is welcome. For example, the NZ startup Publons (https://publons.com/) seems to have developed into a useful place where referees can get credit for their work. The final (?) step will be to find some way of measuring the quality of that work – sitting on a committee is not the same as actually contributing. I welcome readers' ideas on how we can further incentivize collegial behaviour. The journal PeerJ Computer Science, where the above editorial story is playing out, requires registered authors to contribute to reviewing in a minimal way. I would like to see this policy adopted more widely. Am I overlooking any undesirable consequences?

In the last issue I announced my intention to hand over the job of editor, and (perhaps unsurprisingly) I have been underwhelmed with offers. However all good things come to an end, and I do intend to step down after the next issue. Large parts of the job are semi-automated and the main difficulty comes in trying to persuade people to contribute material. I thank all contributors during my tenure, and hope that the right person is just waiting for the right moment to volunteer to take over.

Mark C. Wilson

Vaughan Jones IMU editorial

(Marston Conder sent the following background to the University of Auckland Mathematics Department. It is reproduced with his permission.)

You might be interested to read the editorial in the latest newsletter from the IMU, written by our own (Sir) Vaughan Jones, on the international nature of mathematics and the universality of mathematics as a language.

The IMU is the "International Mathematical Union", which is an international body representing the interests of mathematicians worldwide. In particular, it runs the 4-yearly International Congress of Mathematicians (and a General Assembly, a meeting of representatives of national mathematical societies), and also organises the award of the Fields Medals and various other prizes.

The current President of the IMU is Professor Shigefumi Mori (a Fields Medal winner from the University of Kyoto, Japan), who recently succeeded Professor Ingrid Daubechies (Duke University, USA), the first woman president.

Vaughan Jones is one of the two Vice-Presidents of the IMU, for the next 4 years. Vaughan studied in this Department in the late 1960s and early 1970s, up to Masters level, did his PhD at the University of Geneva, and went on to have a great career, winning the Fields Medal in 1990 (for his work on von Neumann algebras and some completely unexpected discoveries on the classification of knots), and many other awards since. (He's also famous for having worn an All Blacks rugby jersey on the stage when he was awarded the Fields Medal by the IMU.)

Vaughan has been the driving force behind the NZMRI, which runs the summer mathematics meetings in New Zealand each year. He spent much of his working life at the University of California Berkeley, and is currently the Stevenson Distinguished Professor of Mathematics at Vanderbilt University (Nashville), and a part-time Distinguished Professor of Mathematics here at Auckland.

Editorial for IMU Newsletter by Vaughan Jones

The IMU is nothing if not international!! My experience on the Executive committee so far has been an adventure in the multicultural and multilingual, with committee members from all over the globe and meeting places to match. Seoul, Berlin, and soon Kyoto, in preparation for an ICM in Rio de Janeiro. One really does feel like a citizen of the world. It is in stark contrast to my upbringing in New Zealand where I never set foot outside the country until I was 21 and moved to Geneva to begin a PhD, and a new global life.

Without a doubt, underlying all this internationalism is the universality of mathematics as a language. The number 27 is $3 \times 3 \times 3$ in any country, planet or galaxy. No civilization powerful enough to consider such questions could disagree. The only differences would be those of notation.

This universality was the essential ingredient of a "conversation" I had recently in Kyoto. I gave an hour long talk to an undergraduate audience on knots and braids. Afterwards some students were keen to understand the exact workings of the algorithm I had given to calculate the Alexander polynomial of a link in 3 space. My Japanese? Non-existent. Their English? Certainly a lot better but still nowhere near adequate to understand my ravings. Nothing was getting across until I just said "watch", and proceeded to draw some pictures and equations on the board. Within a couple of minutes they understood the concept and the method and took off calculating away, just as well as I could have. And this could have happened in any country, with any language.

Mathematics is a component of human understanding of the universe that transcends linguistic and cultural barriers. So it is fitting that the IMU Executive committee be truly international and take global balance into account in all of its decisions.

PRESIDENT'S COLUMN

The Mathematics-in-Industry for New Zealand Study Group took place just a month ago here at Albany. I found myself staring at a partially dismantled clothes dryer. Meanwhile, downstairs they were considering cows and milk powder (in different rooms) and upstairs they were considering criminals. It was an interesting and instructive week and it was good to see a range of mathematicians participating and especially students. Graeme Wake reports on the overall event elsewhere in this newsletter.

Next month (September), the former President of the International Mathematical Union, Ingrid Daubechies from Duke University, will be visiting as the 2015 Maclaurin Lecturer. Catch her seminar at a department near you. Thanks to Florian Beyer who is coordinating this tour.

Also in this latter half of the year, Steven Galbraith will be touring the UK as the Aitken Lecturer. In New Zealand, the students have the NZ Mathematics and Statistics Postgraduate Conference (Taupo in November).

The NZMS Colloquium is at the start of December at University of Canterbury. Rua Murray has recently announced that registrations are open. The inaugural Butcher-Kalman Speaker at the Colloquium will be Adam Day and the NZMS Speaker will be Rick Beatson. The other invited speakers are Claire Postlethwaite (ANZIAM speaker), Catherine Greenhill and Ian Frigaard.

I congratulate Gaven Martin on his appointment to the ICSU Committee on Freedom and Responsibility in Science.

I would like to record grateful thanks to Douglas Bridges who has stepped down after a very long period of service on the governing committee of the New Zealand Journal of Mathematics, during which time the journal has seen much change. Shaun Cooper will replace Douglas as an NZMS representative.

Winston Sweatman

READERS' FORUM

Please send your Letters to the Editor (as usual, the editor's decision is final and excessively long ones may be abridged), requests for collaboration, etc. Anything that genuinely helps create useful discussion and interaction between members on topics related to mathematics is desirable.

From Garry J. Tee

(publication charges are not a new phenomenon)

In 1958 I realized that electronic digital computers were going to become extremely important (when very few people understood that), and so I went to England to get into computing. From 1958 to 1964 I was a consultant mathematician to English Electric Company, which was the largest engineering firm in the UK.

I did much work on methods for solving large systems of finite-difference equations. In 1963 I wrote a large paper on a new technique for solving elliptic PDEs without factorization, and I submitted that to the Journal of the Society for Industrial and Applied Mathematics. After some minor revision my paper was accepted in 1963 by the Editor who then sent me a bill to English Electric Co. for a publication charge of about $800 (I think)! My boss Dr Peter G. Wakely in English Electric Company was outraged by that extortion and he sent a furious letter to the Editor, who replied immediately (by airmail). He explained that almost all of the mathematicians publishing in JSIAM were funded by the US Navy, which paid without questioning any charges required for publishing their work. The Editor assured Dr Wakely that he had never intended to charge English Electric Co. for publishing my paper.

And thus my 37-page paper "A new technique for solving elliptic partial differential equations" did get published in JSIAM, in 1964. I regard that as one of my most important papers. Valerii Pavlovich Il'in (Novosibirsk University) promoted that paper prominently in his 1970 textbook, and in his treatise "Iterative Incomplete Factorization Methods" (World Scientific, 1992), but the papers by Werner Liniger (1989) and K. E. Khor (1990) are the only publications that I know of which applied my method.

MATHEMATICAL MINIATURE

MM37: Locating zeros

Given a polynomial

$$P(z) = a_0 z^n + a_1 z^{n-1} + \cdots + a_n, \qquad (*)$$

with real coefficients, we might be curious to know where the zeros are located relative to the imaginary axis. If we knew the answer we would know something about the long-term behaviour of solutions to the differential equation

$$a_0 \frac{\mathrm{d}^n y}{\mathrm{d}x^n} + a_1 \frac{\mathrm{d}^{n-1} y}{\mathrm{d}x^{n-1}} + \cdots + a_n y = 0.$$

Define $(*)$ to be an A-polynomial if all its zeros are in the open left half-plane. If this is the case then $|y(x)| \to 0$ as $x \to \infty$. Today we will look at a version of the Routh–Hurwitz criterion for P to be an A-polynomial. First a necessary condition.

Lemma 1. *If P is an A-polynomial with $a_0 > 0$, then $a_i > 0$, $i = 1, 2, \ldots, n$.*

It is known that the zeros of P' lie in the convex hull of the zeros of P hence they also lie in the left half-plane. The product of the negatives of the zeros of $P^{(n-i)}$ is $a_i / \binom{n}{i} a_0 > 0$.

Remark 2. Scaling the odd numbered coefficients in P by a positive factor t to give $a_0 z^n + t a_1 z^{n-1} + a_2 z^{n-2} + t a_3 z^{n-3} + \cdots$ makes no difference to a polynomial being an A-polynomial or not.

If this were not the case, we could use a homotopy argument to find the first t greater or less than $t = 1$ for which z or $z^2 + K$ becomes a factor with $K > 0$. It is found that this is also a factor of the original P.

Let

$$Q_t(z) = P(z) - \tfrac{1}{2} t z \big(P(z) - (-1)^n P(-z) \big) \qquad (\dagger)$$

Theorem 3. *P is an A-polynomial if and only if Q_t is an A-polynomial for $t = a_0/a_1$*

This is proved in the only if direction in a similar way to Remark 2 for $t \in [0, a_0/a_1)$. That is, as t increases above zero, it is not possible that zeros cross the imaginary axis. In the last instant as the z_n coefficient in Q_t vanishes, a zero tends to $-\infty$. The if result follows from the observation that $P(z) - (-1)^n P(-z)$ can be replaced by $Q_t(z) - (-1)^n Q_t(-z)$. This process can be repeated until the polynomial under immediate study is a constant. That is define $P_n(z) = P(z)$, and P_{n-1}, P_{n-2}, …, P_0, in turn with each P_k found from P_{k+1} in the same way that Q_t was found in (†). In the end we have, as a necessary and sufficient condition for P to be an A-polynomial, the criterion that all the leading coefficients of P_n, P_{n-1}, …, P_0 have the same signs.

A related question is whether or not all zeros of $(*)$ are in the open unit disc. But this question is only a Möbius transformation away from the one we have been discussing. There is also a direct algorithm for answering this question and it works even if the coefficients are complex numbers. With the unit disc question we have a criterion for the powers of a matrix converging to the zero matrix. It has also been suggested as the central tool in iterative algorithms for solving polynomial equations.

Recently I was reminded of the old question of determining whether a collection of 12 marbles all weigh the same or, if this is not the case, which single marble is too heavy or too light. This is to be done with three weighings on a balance. There is a simple theorem about this problem: the first weighing must have 4 marbles on each side, otherwise a further two weighings would not be able to settle the answer for each outcome. Hence, naming the marbles as A, B, C, …, L, we can, in the first weighing, place A, B, C, D on one side and E, F, G, H on the other side. This first weighing will narrow down to two cases (i) one of A, B, C, D is too heavy or one of E, F, G, H is too light or (ii) if there is any faulty marble, it must be one of I, J, K or L. In case (i) the second weighing could consist of A, B, E on the left side and C, D, F on the right side. If these balance, then one of G, H is too light and a third weighing can easily decide between these possibilities. If the left is too heavy, one of A or B is too heavy or F is too light and again, a third weighing will settle the result. If the right is too heavy in the second weighing, then C or D is heavy or E is light. Again a third weighing will distinguish these cases. I remember from when this puzzle was in vogue 60 years ago, a solution was known in which the second and third weighings were specified a priori. I would enjoy hearing from anyone who can find this solution.

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

CYBERMATH

Impressive though this newsletter is, we must read more in order to obtain a full picture of mathematical events.

- The International Mathematical Union Newsletter (http://www.mathunion.org/imu-net) is issued bi-monthly. An editorial by Vaughan Jones is in the latest issue, and there are several other interesting articles.
- The Asia-Pacific Mathematics Newsletter (http://www.asiapacific-mathnews.com/) has reprinted some of our articles, and has many others worth reading.
- There are many blogs written by mathematicians and it is hard to keep up. The American Mathematical Society has a Blog on Math Blogs (http://blogs.ams.org/blogonmathblogs/). The Aperiodical (http://aperiodical.com) is a shared blogging site, as is Mathblogging.org (http://www.mathblogging.org/).
- Prominent individual mathematical bloggers include
  - Terence Tao at What's New (https://terrytao.wordpress.com/),
  - Timothy Gowers at Gowers's Weblog (https://gowers.wordpress.com/),
  - John Baez at Azimuth (https://johncarlosbaez.wordpress.com/),
  - Tanya Khovanova (http://blog.tanyakhovanova.com/) and
  - David Mumford (http://www.dam.brown.edu/people/mumford/blog.html).

I am not aware of any active mathematical blog by an NZ-based author. I have looked at Twitter but have not found any compelling use for it as far as mathematics goes. Perhaps it makes more sense for faster-moving fields. I would like to be proved wrong by readers with experience of productive use of that platform.

Reading long texts is increasingly rare in the internet age. Video is now heavily used in some fields by authors to promote their papers, although I haven't seen this in mathematics. More interestingly, there is a huge number of videotaped lectures available. The Banff International Research Station has well over 3000 research-level mathematics lecture videos (http://www.birs.ca/videos/). Igor Pak has a collection of combinatorics videos (http://www.math.ucla.edu/~pak/lectures/Math-Videos/comb-videos.htm) and a discussion of why this is important (https://igorpak.wordpress.com/2015/05/02/you-should-watch-combinatorics-videos/). I always try to record (even if just voice and slides) every talk at every conference I am involved in organizing.

Popular culture has a long history of misrepresenting mathematics and mathematicians. However there are exceptions. The New York Times has a recent article about Terry Tao (http://www.nytimes.com/2015/07/26/magazine/the-singular-mind-of-terry-tao.html). Among other very interesting parts about Tao, I found Charles Fefferman's analogy between mathematical research and playing chess against the devil to be insightful.

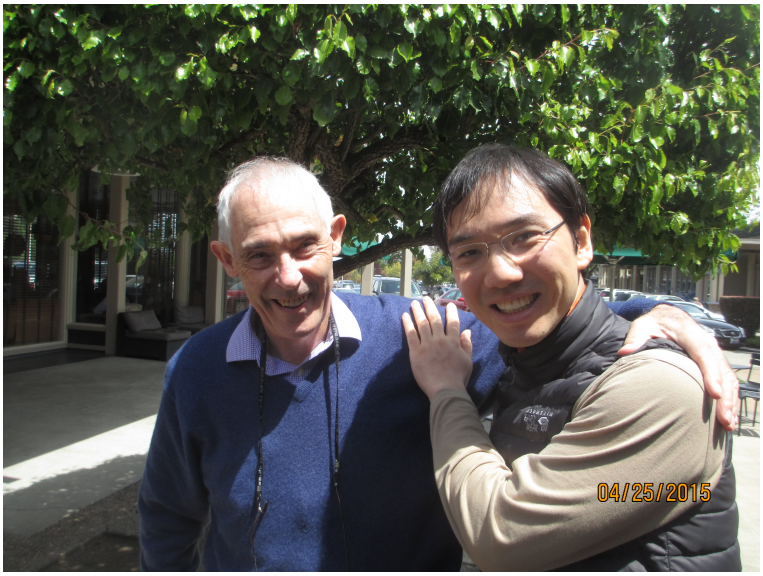
Mark C. Wilson

WHERE ARE THEY NOW?

Michael A. Saunders was brought up in Christchurch and graduated BSc(Hons) in Mathematics from the University of Canterbury in 1965. He was the subject of a brief Centrefold article in this Newsletter (issue 36, 1986).

Mike has been based at Stanford University for most of his career after a few attempts in the 1970s to work in NZ (at the Applied Maths Division of the DSIR). He received his PhD there under Gene Golub in 1972 and has worked mostly on numerical methods in linear algebra and optimization. He has received the William Orchard-Hays Prize in Computational Mathematical Programming, Mathematical Programming Society (1985) and SIAM Linear Algebra Prize (2012), and been elected an Honorary Fellow of the Royal Society of New Zealand (2007) and SIAM Fellow (2013). He was inducted into the Stanford University Invention Hall of Fame for his work on optimization software, with Philip Gill, Walter Murray, Bruce Murtagh, and Margaret Wright. He has maintained relationship with New Zealand, being a member of the International Scientific Advisory Board of NZIMA throughout its existence. His twin brother David has had a long career as a numerical software engineer at NASA.

We asked him some questions by email. The photo shows him (left) with a former student.



NZMS: What do you consider your career highlight in terms of research contribution (feel free to be technical here because the article will have very little technical stuff)

MAS: I have worked on algorithms and software in two areas of scientific computing called "numerical linear algebra" and "numerical optimization". They help solve mathematical problems in engineering, science, business, and so on. Algorithms are the mathematical part, and software is the tangible part: the computer programs that allow others to make use of your work.

When you write general-purpose software, you become associated with the names of the computer programs and some all-important coauthors. SYMMLQ and MINRES (with coauthor Chris Paige) became popular solvers for large systems of equations; they can handle more general systems than the classical conjugate-gradient method. LSQR (Chris Paige) and LSMR (David Fong) solve large least-squares problems; they help geophysicists keep supercomputers busy all year with the search for oil. MINOS (with Christchurch colleague Bruce Murtagh) pioneered large-scale constrained optimization and continues to be much used within the GAMS and AMPL modeling systems.MINOS paved the way for SNOPT (with English colleagues Philip Gill and Walter Murray). SNOPT is especially known in aerospace for shape optimization and trajectory optimization. A current highlight is Jacob Englander's EMTG system (Evolutionary Mission Trajectory Generator) at NASA's Goddard Space Flight Center. EMTG calls SNOPT millions or even billions of times to design optimal spacecraft missions to the planets, comets, and asteroids. It's our best hope for planning exploration of the solar system, and for stress-testing our all-too-complex optimization software.

NZMS: What things did you do in your career that would simply not have been possible in NZ?

MAS: Conferences are an essential part of research. I've attended endless conferences since 1970, mostly in the US and Europe. From New Zealand's point of view, California is halfway to Europe and much nearer the centres of activity. When I was in Wellington in December 1973, I was fortunate to attend the Gatlinburg meeting in Bavaria, Germany. This is when I realized that the world is still a big place. We flew over night-time fires in Jakarta; we refueled in Bombay beside soldiers armed with World War I .303 rifles; we were able to cross Iran; we experienced a white Christmas in Bavaria. My round trip cost the German organizers more than for any other attendee. I could not expect to attend many other international meetings from Wellington.

Coauthors arise from conferences and from working at a prominent institution.I met most of my coauthors during student days at Stanford University, partly because of conferences but also because they visited Stanford.

NZMS: You have kept in contact with NZ mathematics to some extent over the years. What is your overall impression of the NZ math scene?

MAS: My main contact was in 1998 (four months of teaching in Engineering Science at Auckland) and in 2002–2007 as a member of the International Scientific Advisory Board of NZIMA. I was deeply impressed by the activity and achievements of NZIMA under the leadership of Marston Conder and Vaughan Jones, and I felt it fully deserved continuing support from the NZ government. I used to return every year or two and see my mathematical colleagues in NZ, but since my mother died in 2006 I regret that I have not managed to visit. Not even since the earthquakes that so affected my older brother and school-time friends.

Nowadays my main awareness of science events comes from the newsletters of the Royal Society of NZ and of Fulbright NZ. Occasionally serving as a referee for academic appointments has highlighted the contributions of NZ colleagues in Operations Research.

I was especially glad to see John Butcher in January 2014 at a conference in the unlikely venue of Sultan Qaboos University in Oman. I know John has been a superstar throughout his career, and it was clear that his enthusiasm for conducting research and sharing his knowledge is as strong as ever. Equally clear was his dismay at having to retire from the University of Auckland, with no further chance to advise graduate students. This is as unfortunate as George Dantzig being born one year too soon. Dantzig was forced to retire from Stanford just before the US Government made mandatory retirement (from most professions) unlawful. Dantzig reached some settlement with Stanford. I sincerely hope that John will find contentment somehow during his remaining years of unfailing creativity.

NZMS: Do you have any advice for NZ math students thinking of pursuing a career in the US?

MAS: Many of Auckland's Engineering Science students have come to Stanford to what is now called Management Science and Engineering. Some are drawn to MIT (they must prefer white Christmases!), but if you like to play tennis you should definitely come to Stanford! Professors Dantzig, Lieberman, and Veinott are gone, Professors Cottle, Eaves, and Hillier are retired, but there's a generation of younger faculty who specialize in social networks, graph theory, national security, energy and environment, investment, supply chains, healthcare systems, entrepreneurship, and more. While not pure mathematics, these subjects all depend greatly on mathematics and computation.

NZMS: What do you miss most about living away from NZ for so long?

MAS: During visits to NZ I have always felt like a real kiwi. I miss seeing the All Blacks in action. This was a highlight of visiting David Ryan's home in 1998. Recently my colleagues managed to tune in to NZ's win over the Springboks in Johannesburg. I was astonished to find that the scoring system had changed from $3+2$ for a try and conversion! During the 1970s I remember being struck by the wonderful earthy taste of vegetables in NZ. Probably this is still true. I hope kiwifruit are plentiful and top quality too (not just remnants from the export trade).

NZMS: What are your plans for the next few years: keep powering along, retirement, etc?

With John Butcher as a fine example, I have no wish to retire. My work environment in ICME at Stanford could not be more friendly or conducive to research. Students from around the world keep me young. The only drawback is that as a Research Professor at Stanford I've had to raise 96.25% of my salary from grants or royalties. This is increasingly difficult.

NZMS: Tell us about your activities other than mathematics.

MAS: I always say that I live in Palo Alto because I love to play tennis. Lunchtime doubles with Stanford colleagues during the week, and Sunday mornings with colleague Gerd Infanger, twin brother David, and his son "Baby Michael". The top women players come to Stanford every August for the Bank of the West Classic (before the US Open), and they are always inspiring. This year I saw Caroline Wozniacki vs Varvara Lepchenko, interrupted a few times by some most unusual drops of rain. In Palo Alto we can play almost year-round.

Long ago, David gave me a CD player for my office. I thought I could never work with music playing, but I soon became familiar with the great arias of opera, and more recently the Mahler symphonies that David has acclaimed for years. Once you know such works you want to see them live, and you want to play them on the piano. Since 1996 I've had a Mason and Hamlin grand piano at home. It's my most precious possession, not counting my 2003 (first-model) Prius and two sweetheart daughters Tania and Emily.

NZMS: Please clarify how you ended up at Stanford. Also, when did you meet John Butcher?

MAS: In 1962 during my BSc (Hons) at Canterbury, John Butcher taught my first class in Numerical Mathematics and raised my interest in computation. John would have taught a follow-on class, but he went off to a strange place called SLAC (the Stanford Linear Accelerator Center). A fellow student Bob Doran (one year ahead of me) also went off to a new Computer Science Department at Stanford.In 1966 I became a civil servant in Wellington at the Applied Maths Division of DSIR. I shared an office with Kit Withers, who went off to the Statistics Department at Stanford. With Kit's encouragement I applied a year later to Computer Science. Little did I know how lucky I was to be admitted, and how much of my life would ultimately be at Stanford. My twin brother David came to visit me in 1970 after five years of teaching mathematics at Aranui High. He was going to stay one month. In the end he was lucky like me in meeting my advisor Gene Golub. He did an MS in Computer Science at Stanford and joined a software company at NASA Ames Research Center nearby. He is there to this day, and as mentioned we are able to play tennis at Stanford most Sundays.

Aerospace has always had the best applications of optimization. David has worked on many intriguing projects such as supersonic airliners and the next space shuttle. Often they are cancelled, but the Mars Lander was successful and the Apollo-like Orion capsule is likely to be, if NASA's budget survives the inevitable pressures.

At Linwood High, David and I would say we wanted to be aircraft designers, with no idea of what that really entailed. We read every page of the British journals "Flight" and "The Aeroplane" and built a 6-foot scale model of the English Electric Lightning twin-jet fighter. At Canterbury, English maths professor Derek Lawden (FRSNZ) was in demand at Boeing and Lockheed for his expertise in trajectory optimization, and Wellington's William Pickering was Director of JPL in Los Angeles. I'm sure these two oriented our thoughts toward the US. I'm glad to feel that David's optimization work at NASA Ames has given concrete form to our childhood ambition. We could not imagine it correctly before computers were commonplace and we studied numerical computation, and it would not have happened if we stayed in NZ.

At heart I still feel very much a kiwi. David says he's afraid to go home now to a Christchurch he won't recognize. I do want to see friends and relatives there, and to visit colleagues in Wellington and Auckland.I missed many of them this year at the 3-yearly International Symposium on Mathematical Programming (the first ISMP I've missed since 1970). It has always been in August but was moved this year to July! Instead, I had 5 weeks of conferences and teaching in Scotland, France, and Switzerland. I am forever grateful that my mother persuaded Linwood High to teach the science students three years of French.

Mathematics and computer science are one way to see the world. I recommend them unreservedly to NZ's students, and I remind everyone that Stanford is on the way to Europe. Please come and visit!

Mark C. Wilson

PROFILE

David Wall

Professor David Wall (pictured, in one of his favoured environments) retired from the University of Canterbury's Department of Mathematics and Statistics at the end of June 2015. He had served as a member of its staff for over thirty years, since 1984. This included his time as Professor of Applied Mathematics (2007–15) which he did with distinction, continuing the long line of Professors in (Applied) Mathematics at the University of Canterbury, which includes notable names like Charles Weatherburn (1924–29), Derek Lawden (1956–67) and Roy Kerr (1971–94). He also embraced the ethos of Engineering Mathematics pioneered so well earlier by the long-serving Emeritus Professor Brian Woods who was the first full Professor in that subject.

David began his University studies in Engineering at the University of Auckland with a first class honours degree in 1971, having first done an NZ Certificate in Engineering (Telecommunications) at the then Auckland Technical Institute. (The latter was a great qualification and, to reminisce, I would have been an external examiner in Mathematics at the time David came through these examinations!!). This underlines the point about the value of links across different levels of the tertiary qualification network. Lured by the activity of the iconic late Richard Bates, then at the University of Canterbury's Electrical Engineering Department, David completed his PhD in 1976 with a thesis entitled: "The null field approach to diffraction theory". That set the scene for what followed. In the late 1970s he spent a couple of years in research fellowships in Scotland and the US, thereafter returning to NZ to take up a succession of positions in the Department of Mathematics and Statistics in 1984. This served to enhance further the links between Mathematics and Engineering, with increased shared teaching and research which has proved of mutual value, and should be retained.

David's research blossomed at Canterbury. He developed a leading profile in the theory of inverse problems in engineering applications and developed new techniques for identifying key underpinning processes with unerring precision. Research students expanded and invitations to speak followed in quick succession. I was indeed fortunate myself to lure him further into the realm of mathematics-in-medicine and we had much satisfaction developing a project on modelling dynamical behaviour of cell-populations. This work was driven by the application to tumour-cell growth and was well cited internationally. A large group still pursues this in collaboration with people

both here and overseas. His current interests are impressive. These cover major areas of Mathematics and Applied Mathematics: the aforementioned area of Mathematical Biology, Applications of Dynamical Systems theory, Inverse Problems, Mathematical Wave Theory and significant areas of Numerical Analysis. His publications show high impact. A quick look at his publication citations shows David has an H-index of over twenty, which is high for the mathematical sciences.

At Canterbury, he is warmly remembered for his steady stewardship of somewhat unsettled times and steered the Department through restructuring which benefitted from his very even-handed calm approach to competing groups He led the way in shifting the Department to the College of Engineering as its primary grouping and led the development of a new major in the BE degree in Engineering Mathematics. The Canterbury earthquakes also provided challenges which were somewhat formidable. He was a very popular Head of Department for two terms (2003–9).

David is held in high regard by all colleagues who know him, many from afar. He is very people-focussed and enjoys many wide interests outside of mathematics. Though he is now nominally 'retired', he will remain in touch with the Department and continue his research interests here and in Europe unencumbered by the heavy demands of modern-day academic life. We wish David and his wife Frances many happy times ahead, and confidently expect he will now see more of the splendid scenery in the photograph shown above.

Graeme Wake

LOCAL NEWS

AUCKLAND UNIVERSITY OF TECHNOLOGY

SCHOOL OF COMPUTING AND MATHEMATICAL SCIENCES

Announcement

A new professional qualification, the Master of Analytics, is being introduced this year. The degree is to equip students with advanced analytics and database skills needed by industries. It is a 180 point program (1.5 years full time or 3 years part time).

The about-to-be-created Department of Mathematical Sciences invites applications from suitably qualified candidates for a professorial position within the field of analytics and data science. Preference will be given to those with a PhD (or equivalent) in a data science related field such as mathematics, statistics or operations research, and preferably a track record of research with industrial and/or business applications. The successful candidate will be expected to have good people skills and provide leadership in the Department's Analytics programmes including the new master's degree in analytics.

Events

From the 8th to 12th June, the AUT–SAS workshop, facilitated by SAS, was held at AUT. Several staff members attended the workshop to develop a solid foundation for SAS programming.

On the 18th June, the School of Computer and Mathematical Sciences held a social event in commemoration of John Nash. A group of speakers (Jiling Cao, Matthew Ryan, Ji Ruan and William Liu) talked about the life and mathematical achievements of John Nash, the influence of his work in economics, artificial intelligence and computer network modelling.

From the 7th to 10th July, the NZAMT (New Zealand Association of Mathematics Teachers) conference was held at AUT. Several staff (Robin Hankin, Murray Black, Murray Jorgensen, Wenjun Zhang, Alna Van Der Merwe and Alla Shymanska) were at the AUT exhibition both to talk to teachers and to distribute SCMS posters and brochures to promote our programmes.

On the 9th July, the Industry Engagement for Research workshop was held to discuss the importance of engaging with industry to increase the effectiveness and relevance of our research outputs. The main message of the workshop is that working with industry is not only a good idea for learning and teaching activities, it is also a great way to produce quality research.

A large group of staff members and students went to the Albany campus of Massey University to participate in the Maths in Industry NZ Study Group (MINZ) to work on 6 challenges proposed by industry.

Travel and Conference Participation

Prof. *Jiling Cao* participated in the 14th European Workshop on Equilibrium Theory, held in Naples, Italy, from 29th June to 1st July. After the workshop, he visited the University of Vigo to work with Prof. Carlos Hervés-Beloso on various topics in Economic Theory for a week.

Prof. *Jeffrey Hunter* has been busy continuing his research into a variety of computational techniques for computing the key properties of Markov chains. Jeff's major activity has been the organisation of the 24th International Workshop on Matrices and Statistics, at Hainan Normal University, 25–28 May 2015. He chaired the International Organising Committee and introduced a number of specialised mini-symposia on a variety of topic areas. The Workshop has been an outstanding success with over 130 registrants and speakers from over 20 countries.

Drs *Kate Lee* and *Sarah Marshall* travelled to the USA in April 2015 to attend two events organised by the statistical software company SAS; Data Science and Advanced Analytics Forum in Cary, North Carolina, and SAS Global Forum in Dallas, Texas. Delegates from academia, industry and government around the world discussed the latest developments within the fields of analysis and big data. While in North Carolina, Kate and Sarah both gave a research seminar in University of North Carolina at Chapel Hill and visited the Institute for Advanced Analytics at North Carolina State University.

Wenjun Zhang

UNIVERSITY OF AUCKLAND

DEPARTMENT OF MATHEMATICS

Tanya Evans has been selected as the CLeaR Fellow for Science in 2016. The CLeaR Fellowship Programme brings together 8 academic staff who are recognised as leaders in the scholarship of teaching, and it provides a structured opportunity for them over the course of an academic year to reflect on a number of related themes. Tanya's selection for this programme is a reflection of her outstanding contributions to high-quality teaching, from which our Department greatly benefits.

Garry Nathan has completed his PhD.

Mirko Wojnowski and his wife Krystal celebrated the arrival of a son to join their 2 daughters.

Dr Tim Burness (University of Bristol) visited us in June, as the inaugural recipient of the Kalman Visiting Fellowship.

Ban Heng Choy has completed his PhD.

The 2015 Auckland Mathematical Olympiad was held on Saturday May 2nd. Almost 150 secondary students representing schools from Albany to Karaka spent 2 hours, tackling 8 problems prepared by Arkadii Slinko and Igor Klep.

The overall winners were Andrew Chen, St Kentigern College, Y9–Y10 (Junior), and Amay Aggarwal, King's College, Y11–Y12 (Senior). Phil Kane devoted very much energy to organising that event, with strong support from other members of the Department.

The Student Research Conference, organised by Dimitri Leemans, Shayne Waldron, Shixiao Wang, and Wes Maciejewski, was held on June 8th. The following talks were presented by graduate students: Jesse Hart (PhD), "Polynomial hulls and extremal functions"; Anton Gulley (PhD), "Fault zone guided waves on the Alpine fault, New Zealand"; Marcus Anthony Triplett (BSc Hons), "Reverse mathematics of the Jordan decomposition theorem for functions of bounded variation"; James Hannam (PhD), "Phase near infinity"; Dhanya Surith (PhD), "The use of the history of mathematics in university lecturing – mathematicians' perspectives"; Rebecca Turner (PhD) "Birds use the magnetic field to navigate"; Matthew Conder (BSc Hons) "Triangle generation of groups"; Sean Curry (PhD), "Cauchy–Riemann geometry and twisting tractors"; Jose Mujica (PhD), "Invariant and slow manifolds near a singular Hopf bifurcation"; Kam–hung Yau (MSc), "Determinantal representation of plane curves"; Saeed Farjami (PhD), "Spike adding in plateau bursting"; Gareth Gordon (PhD), "Friedlander's eigenvalue inequalities"; Ben Lawrence (PhD), "Linear matrix inequalities and spectrahedra"; Joel Laity (MSc), "Group-Based Cryptography"; Andrus Giraldo (PhD), "Global invariant in the neighbourhood of a homoclinic flip bifurcation"; Nina Anchugina (PhD), "A simple framework for the axiomatization of exponential and quasi-hyperbolic discounting"; Abhishek Bhardwaj (MSc), "The truncated moment problem"; Tan Do (PhD), "Core properties for degenerate elliptic operator"; Sarah Schinke (MSc), "Changing the language of instruction in mathematics: The experience of European immigrants to New Zealand"; Andrew Keane (PhD), "Bifurcation analysis of model for the El Niño southern oscillation". The programme proved to be highly-successful, and the overall prize winners were Sean Curry, Anton Gulley and Joel Laity.

Our PhD student *Sylvia Han* won the First Prize for her poster entitled "A Mathematical Model of Calcium Dynamics in Salivary Duct Cells", which she presented at the postgraduate satellite conference to the 2015 Gordon Research Conference on Calcium Signalling, held in June at Maine.

Visitors

Recent visitors include: Dr Said Ali Algarni (King Fahd University of Petroleum and Minerals, Saudi Arabia), Dr Maria Bruna (University of Oxford), Dr Nigel Calder (Waikato), Prof. Martin Falcke (Max Delbrück Center for Molecular Medicine), Prof. Christine Franklin (University of Georgia), Dr Andy Hammerlindl (Monash University), Dr Martin Homer (University of Bristol), A-Prof. Edward Huang (National Chang Kung University, Taiwan), Dr Jodie Hunter (Massey University – Albany), Prof. Barbara Jaworski (Loughborough University), Dr Beatrix Jones (Massey University – Albany), Prof. Igor' Kontorovich (Simon Fraser University), Dr Kerry Landman (University of Melbourne), Dr David Landy (Indiana University), Dr Andree Lischewski (University of Adelaide), Prof. Jean–François Maheux (Université du Québec à Montréal), Prof. Asia Matthews (Queen's University, Kingston, Ontario), Prof. Robert McKibbin (Massey University – Albany), Prof. Eduardo Morais (University of Campinas, Brazil), Prof. Primoz Moravec (University of Ljubljana), Dr Katharina Neusser (ANU), Dr Katsutoshi Shinohara (Tokyo Metropolitan University), Prof. Nathalie Sinclair (Simon Fraser University), Dr Sepideh Stewart (University of Oklahoma), Dr Mirian Tsulaia (University of Canberra), Prof. Andrew Waldron (UC – Davis) and Prof. Margaret Walshaw (Massey University – Albany).

Garry J. Tee

DEPARTMENT OF STATISTICS

Quite a few things have happened over the last year. *James Russell* received a Rutherford discovery fellowship investigating "Conservation complexity: scaling vertebrate pest control". Congratulations James.

Chris Triggs stepped down as HoD. We thank Chris for his six years of service to the department. *Ilze Ziedins* took over with energy and drive, and if a colleague needs energy she might just have some chocolate in her office.

Alan Lee went into partial retirement in April 2015, and is enjoying the reduced teaching load and increased time for research and family.

We welcomed three new colleagues to the department, Dr *Jesse Goodman*, Dr *Yalu Wen*, and *Anna-Marie Martin*.

Jesse joined us as a lecturer in 2014. He completed his undergraduate and PhD studies at the University of British Columbia, then held postdoctoral fellowships at Eindhoven University of Technology, Leiden University and the Technion. His current research addresses how extreme geometric behaviour in Brownian motion

arises as a combination of local and global effects. His other research interests include percolation-type processes, couplings, and random networks.

Yalu joined us as a lecturer in 2014. Her research interests primarily lie in statistical genetics. Specifically, she is interested in developing and evaluating new statistical genetic risk prediction models for both population-based and family-based studies using high-dimensional sequencing data (e.g., building genetic risk prediction models within the random field framework). In parallel with this line of research, she is also interested in the development and application of new statistical methods for genome wide association analysis.

Anna joined us as a Professional Teaching Fellow in early 2015. She is part of the STAT10x team. Before joining the department she was the Director for Mathematics and Statistics at Avondale College, one of the 3 largest secondary schools in New Zealand. She is interested in statistical education, in particular curriculum and assessment design, and enjoys facilitating workshops to support professional development of statistics teachers. She has worked with the New Zealand Ministry of Education and the New Zealand Qualifications Authority on the development of national assessment standards, tasks and teaching resources for statistics. She is a member of the NZSA education committee.

On the personal side of things, congratulations to Thomas Yee on the birth of his daughter Annie, and Steffen Klaere on the birth of his son Michael. We wish them all the sleep they can get.

Visitors

There were a few guests coming and going through the department:

David Balding, University of Melbourne and UCL Genetics Institute London visited for a few days in June 2015. He gave a seminar on the bones of Richard III.

Randall Pruim from Calvin College, Grand Rapids, MI visited the department for six months in 2015. Randall gave a very interesting seminar on the introduction of R to beginners.

Volkmar Liebscher from the University of Greifswald, Germany visited in January 2015. He gave a presentation on "Potts Models for the Segmentation of Time Series".

Steffen Klaere

UNIVERSITY OF CANTERBURY

SCHOOL OF MATHEMATICS AND STATISTICS

Congratulations to *Mike Plank* who has been awarded a 2015 University of Canterbury Teaching Award. The award was presented on 8th June, during UC Teaching Week.

In May the School welcomed *Blair Robertson* to take up a continuing mathematics lecturing position. Blair is a familiar face to many, having graduated with a PhD in Mathematics from this School in 2010, and having held a fixed term position here from 2011 to 2013. Since then he was at the University of Wyoming in Laramie, USA. His research interests are in numerical optimisation, sampling theory and design, and data mining. Not long after returning to Christchurch Blair had another live changing event, the birth of his daughter Eva in June. Best wishes to Blair and his wife Emma.

Douglas Bridges retired at the end of April after 39 years as an academic. For the last 16 years of his career Douglas was at UC where he held the Chair of Pure Mathematics. He also spent several years as Head of Department. Douglas is well known for his outstanding research and is still involved in the CORCON project. He will continue to have an office here. and was awarded the title of Emeritus Professor by the University Council in February.

At the end of June another leading light in our School retired. *David Wall* has been a highly regarded lecturer and researcher during his 34 years at this university. He has also been influential in shaping the School, especially during his time as Head. David has had an excellent research career and many students have benefited from his teaching. He is well known for his enthusiasm for the NZ outdoors, of which he plans to enjoy more. It was perfect timing that the University Council confirmed the status of Emeritus Professor for David a few days before he officially retired.

In May the School welcomed Erskine Fellow Ian Frigaard from the Departments of Mathematics and Mechanical Engineering at the University of British Columbia, Canada. Ian's field of special interest is Non-Newtonian Fluid Mechanics, and during his six weeks at UC he has been teaching in EMTH210. Ian was hosted by *Miguel Moyers-Gonzalez*, and also interacted with *Phil Wilson*.

During June Elmwood Players, a local theatre company in Christchurch, put on "Proof", a very mathematical play by David Auburn, winner of the 2001 Pullitzer prize and Tony award for best play. Quite naturally, the director Sam Primrose was looking for people who can convincingly play mathematicians. After auditions, master's student Lisa Hall got the role of Catherine, a troubled young mathematician and the daughter of Robert, who was a brilliant but unstable mathematician. Catherine has inherited her father's brilliance but is afraid she has inherited his instability as well.

Lisa recounts her recent experience of 'treading the boards' in the production of Proof: "As the token mathematician in a play about mathematics, I was able to

explain the maths jokes to the rest of the cast and help them to get into the mind of a mathematician. Working on Proof has been an exercise in self-reflection and has challenged me as I've worked to discover my inner actor. The play is both moving and funny as it explores mental illness and the different reactions of characters as they are confronted with this. Working on the play has been a great opportunity but I'm still not quite sure how I feel about being told I was perfect for the role of a crazy person ...."

Günter Steinke

UNIVERSITY OF OTAGO

DEPARTMENT OF MATHEMATICS AND STATISTICS

Known for his markedly friendly and warm-hearted attitude towards his colleagues and students, we bid a sad farewell to *Peter Fenton*. After 39 years of service at the Department, Peter is now entering his well-deserved retirement. Peter was awarded a BSc (First Class Honours) and MSc from the University of Melbourne, and he did a PhD at the Imperial College, London. Afterwards, Peter spent two years at the University of Maryland, before he finally joined the Department in 1976. Well-known for his research in pure mathematics, in particular, complex analysis, Peter was at the same time very interested in the history of mathematics, and he was an outstanding teacher. In the words of a student, "Peter Fenton's calculus lectures are the best show in town." Best wishes for a happy retirement, Peter. We hope that you will occasionally pay a visit to the Department and your old colleagues and friends.

This year's NZMS Forder Lecturer Endre Süli (University of Oxford) visited the Department in April. Endre gave a very interesting public lecture about "Finite difference methods in the 21st century", and a seminar on "Mathematical challenges in kinetic models of dilute polymers".

This newsletter's Otago correspondent is among the five University of Otago academics whose research contributions have been recognised through "University of Otago Early Career Awards for Distinction in Research".

David Bryant, who has recently been promoted to full professor, gave his inaugural professorial lecture. David works on mathematical, statistical and computational aspects of evolutionary biology. In his very well-attended lecture, he told the audience about "Proofs and evolution".

Members of the Department have organised the conference Statistics in Ecology and Environmental Monitoring (SEEM 2015) in Queenstown. There were about 50 participants, mainly from New Zealand, but also from Australia and the USA. Besides an interesting conference, they could enjoy the beautiful scenery with a little bit of snow and plenty of sun.

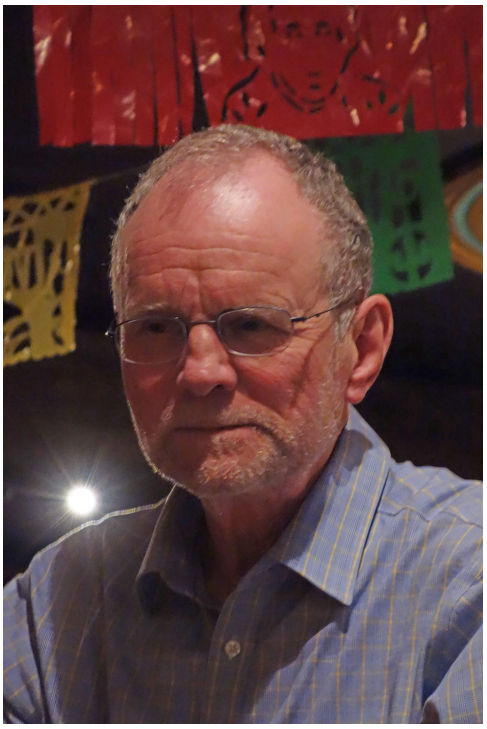
In July, *Astrid an Huef* and *Iain Raeburn* gave lecture courses at a research school on "Leavitt path algebras and graph C*-algebras" at the Nesin Mathematics Village in Sirince, Turkey. The school was sponsored by the European agency CIMPA, whose aims include the promotion of international cooperation in mathematical research in developing countries.

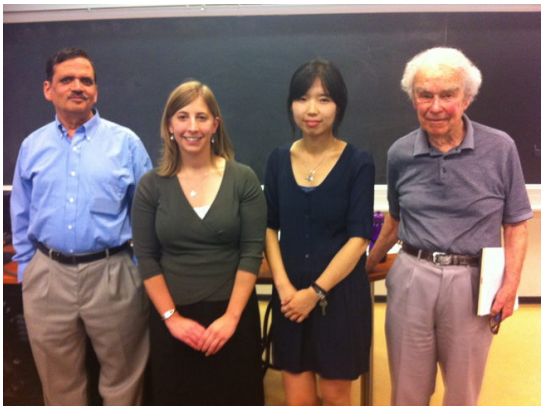
Visitors

The Department had several short term visitors in the past couple of months, who were hosted by *Astrid an Huef*, *Iain Raeburn* and *Lisa Clark*. Marcelo Laca (University of Victoria, Canada) and Aidan Sims (University of Wollongong, Australia) visited in May. Marcelo was working with Iain on dynamical systems associated to self-similar group actions, and Aidan was working with Lisa and Astrid on the quasidiagonality of higher-rank graph algebras. Jon Brown (University of Dayton, USA), who visited us in June, was working with Lisa and Astrid on the Steinberg algebras of graph groupoids.

Jörg Hennig

Colleagues mentioned in Local News reports (left to right, top to bottom): Peter Fenton; Douglas Bridges; Blair Robertson; Vidyadhar Kulkarni, Sarah Marshall, Kate Lee and Ross Leadbetter at UNC, Chapel Hill; Mike Plank being presented with his Teaching Award.





ABSTRACTS OF NZ PHD THESES

Harish Sankaranarayanan, University of Otago

Supervisors: Boris Baeumer and Mihály Kovács

Date: 2015

Title: **Grünwald-type approximations and boundary conditions for one-sided fractional derivative operators**

Error and stability analysis of higher order numerical schemes for (space) fractional partial differential equations (FPDEs) in $L_1(\mathbb{R})$ are carried out using multiplier and semigroup theories. Results from L_1-setting are generalised to function spaces where the translation (semi) group is strongly continuous, using a transference principle. Convergence of Grünwald approximations to fractional derivative operators on $C_0(\Omega)$ and $L_1(\Omega)$, $\Omega = [0,1]$ and the well-posedness of the associated Cauchy problems are established. The culmination of the thesis is the convergence of the well understood processes associated with Grünwald approximations to the processes governed by the corresponding FPDEs in the Skorohod topology.

Ben Clark, Victoria University of Wellington

Supervisor: Geoff Whittle

Date: 2015

Title: **Fragility and excluded minors**

Let $\mathscr{N}$ be a set of matroids. A matroid, M, is $\mathscr{N}$-fragile, if for every element e, either $M\backslash e$ or M/e has no minor isomorphic to a member of $\mathscr{N}$. This thesis gives new results in matroid representation theory that elucidate the relationship between $\mathscr{N}$-fragile matroids and excluded minors.

Let $\mathbb{P}$ be a partial field, and let $\mathscr{N}$ be a set of strong stabilizers for $\mathbb{P}$. The first main result of this thesis establishes a relationship between $\mathscr{N}$-fragile matroids and excluded minors for the class of $\mathbb{P}$-representable matroids. We prove that if an excluded minor M for the class of $\mathbb{P}$-representable matroids has a pair of elements a,b such that $M\backslash a,b$ is 3-connected with an $\mathscr{N}$-minor, then either M is close to an $\mathscr{N}$-minor or $M\backslash a,b$ is $\mathscr{N}$-fragile. The result motivates a study of the structure of $\mathbb{P}$-representable $\mathscr{N}$-fragile matroids.

The matroids $U_{2,5}$ and $U_{3,5}$ are strong stabilizers for the $\mathbb{U}_2$ and $\mathbb{H}_5$ partial fields. The second main result of this thesis is a structural characterisation of the $\mathbb{U}_2$- and $\mathbb{H}_5$-representable $\{U_{2,5},U_{3,5}\}$-fragile matroids. We prove that these matroids can be constructed from $U_{2,5}$ and $U_{3,5}$ by a sequence of moves, where, up to duality, each move consists of a parallel extension followed by a delta-wye or a generalised delta-wye exchange.

Finally, we obtain a bound on the size of an excluded minor M for the class of $\mathbb{U}_2$- or $\mathbb{H}_5$-representable matroids with the property that M has a pair of elements a,b such that $M\backslash a,b$ is 3-connected with a $\{U_{2,5},U_{3,5}\}$-minor. Our proof uses the first and second main results of this thesis.

Loveday Kempthorne, Victoria University of Wellington

Supervisors: Marco Sonzogni and Peter Donelan

Date: 2015

Title: **Relations between Modern Mathematics and Poetry: Czesław Miłosz; Zbigniew Herbert; Ion Barbu/Dan Barbilian**

This doctoral thesis is an examination of the relationship between poetry and mathematics, centred on three twentieth-century case studies: the Polish poets Czesław Miłosz (1911–2004) and Zbigniew Herbert (1924–1998), and the Romanian mathematician and poet Dan Barbilian/Ion Barbu (1895–1961).

Part One of the thesis is a review of current scholarly literature, divided into two chapters. The first chapter looks at the nature of mathematics, outlining its historical developments and describing some major mathematical concepts as they pertain to the later case studies. This entails a focus on non-Euclidean geometries, modern algebra, and the foundations of mathematics in Europe; the nature of mathematical truth and language; and the modern historical evolution of mathematical schools in Poland and Romania. The second chapter examines some existing attempts to bring together mathematics and poetry, drawing on literature and science as an academic field; the role of the imagination and invention in the languages of both poetics and mathematics; the interest in mathematics among certain Symbolist poets, notably Mallarmé; and the experimental work of the French groups of mathematicians and mathematician-poets, Bourbaki and Oulipo. The role of metaphor is examined in particular.

Part Two of the thesis is the case studies. The first presents the ethical and moral stance of Czesław Miłosz, investigating his attitudes towards classical and later relativistic science, in the light of the Nazi occupation and the Marxist regimes in Poland, and how these are reflected in his poetry. The study of Zbigniew Herbert is structured around a wide selection of his poetic oeuvre, and identifying his treatment of evolving and increasingly more complex mathematical concepts. The third case study, on Dan Barbilian, who published his poetry under the name Ion Barbu, begins with an examination of the mathematical school at Göttingen in the 1920s, tracing the influence of Gauss, Riemann, Klein, Hilbert and Noether in Barbilian's own mathematical work, particularly in the areas of metric spaces and axiomatic geometry. In the discussion, the critical analysis of the mathematician and linguist Solomon Marcus is examined. This study finishes with a close reading of seven of Barbus poems.

The relationship of mathematics and poetry has rarely been studied as a coherent academic field, and the relevant scholarship is often disconnected. A feature of this thesis is that it brings together a wide range of scholarly literature and discussion. Although primarily in English, a considerable amount of the academic literature collated here is in French, Romanian, Polish and some German. The poems themselves are presented in the original Polish and Romanian with both published and working translations appended in the footnotes. In the case of the two Polish poets, one a Nobel laureate and the other a multiple prize-winning figure highly regarded in Poland, this thesis is unusual in its concentration on mathematics as a feature of the poetry which is otherwise much-admired for its politically-engaged and lyrical qualities. In the case of the Romanian, Dan Barbilian, he is widely known in Romania as a mathematician, and most particularly as the published poet Ion Barbu, yet his work is little studied outside that country, and indeed much of it is not yet translated into English.

This thesis suggests at an array of both theoretical and specific starting points for examining the multi-stranded and intricate relationship between mathematics and poetry, pointing to a number of continuing avenues of further research.

Lisa Henley, University of Canterbury

Supervisors: Jennifer Brown and Marco Reale

Date: April 2015

Title: **The quantification and visualisation of human flourishing**

Economic indicators such as GDP have been a main indicator of human progress since the first half of last century. There is concern that continuing to measure our progress and/or wellbeing using measures that encourage consumption on a planet with limited resources, may not be ideal. Alternative measures of human progress, have a top down approach where the creators decide what the measure will contain. This work defines a 'bottom up' methodology an example of measuring human progress that doesn't require manual data reduction. The technique allows visual overlay of other 'factors' that users may feel are particularly important. I designed and wrote a genetic algorithm, which, in conjunction with regression analysis, was used to select the 'most important' variables from a large range of variables loosely associated with the topic. This approach could be applied in many areas where there are a lot of data from which an analyst must choose. Next I designed and wrote a genetic algorithm to explore the evolution of a spectral clustering solution over time. Additionally, I designed and wrote a genetic algorithm with a multi-faceted fitness function which I used to select the most appropriate clustering procedure from a range of hierarchical agglomerative methods. Evolving the algorithm over time was not successful in this instance, but the approach holds a lot of promise as an alternative to 'scoring' new data based on an original solution, and as a method for using alternate procedural options to those an analyst might normally select. The final solution allowed an evolution of the number of clusters with a fixed clustering method and variable selection over time. Profiling with various external data sources gave consistent and interesting interpretations to the clusters.

REPORTS ON EVENTS

56th IMO, Chiang Mai, Thailand, 4–16 July 2015

Results

New Zealand had another successful year at this year's International Mathematical Olympiad, which took place in tropical Chiang Mai, Thailand. The team and their results were as follows (individual scores out of 42):

Student	Score	Percentile	Award
Miles Yee-Cheng Lee (Auckland International College)	18	75.87	Bronze
Xuzhi Zhang (Auckland Grammar School)	15	62.50	Bronze
George Han (Westlake Boys' High School)	11	44.27	Hon. men.
Kevin Shen (Saint Kentigern College)	10	41.67	Hon. men.
Martin Luk (King's College)	9	36.81	Hon. men.
Prince Michael Balanay (Botany Downs Sec. Coll.)	9	36.81	Hon. men.
Team result: 49th equal of 104 countries	72	53.40	

Consistent performances across the board saw every member of the team receive at least an honourable mention, awarded for full marks (7 points) on at least one of the six problems. This has only happened four times in our 28 years at the IMO, all within the last six years, and is part of a trend going back to the early 2000s, which has seen the majority of our students who go to the IMO get at least HM. This is a pleasing sign that we've been able to raise the overall performance of team. The solid team performance also served to lift us in the percentile rankings, up from 41.0 last year to 53.4, our sixth best result.

Remarkably, both of our medals this year went to the two members of the team who were attending their first IMO, Miles and Xuzhi. Miles did especially well, with his score of 18 putting him only one point away from silver. The paper was particularly difficult this year, as can be seen in the gold and silver medal cuts of 26 for gold (a new record low) and 19 for silver (also a record low, but previously seen in 1999, 2003 and 2006). This can largely be attributed to problems 2 and 5 (the two "medium" problems) both being much harder than usual: the statistics show that these were comparable in difficulty to problem 3, the easier of the two "hard" problems, with each of problems 2, 3 and 5 being solved by only 30 or 31 of the 577 contestants.

George, our top student over the last two years, was unwell over the couple of days leading up to the contest. This combined with the more difficult paper may in part be why he didn't manage to repeat his 2014 result of silver – something he was clearly very disappointed about. Nevertheless his tally of one silver, one bronze and two honourable mentions from his four IMOs puts him in third place in our "Hall of Fame", behind our only gold medalist Simon Marshall (one gold, one silver, 2001–2002) and Malcolm Granville (one silver and two bronze, 2009–2011). Kevin and Martin both matched their 2014 results of HM, and Prince, the only member of last year's team to miss out on an award, lifted his performance this year to win honourable mention. This was very pleasing to see. Kevin and Miles are both eligible to return next year, and I have invited Miles to attend Australia's December "School of Excellence" training camp – we have an arrangement with Australia where we can send one student to this each year. Both George and Kevin (among others) have benefited from this in previous years.

Overall, the top individual was Alex Song from Canada, the only student to get a perfect score this year. On stage at the closing ceremony to receive an award from the Deputy Minister of Education he mistakenly held the Canadian flag upside-down, and the MC commented he had "a perfect score, with a less than perfect flag configuration". The minister gently and good-humouredly helped him correct this configuration, and then posed with him and the purple elephant he'd just been presented. The top country this year was the USA. With a few exceptions they've been in the top three every year since 2000, but this was the first time they'd won since 1994, beating China, South Korea and North Korea in second, third and fourth places respectively.

Australia are to be congratulated on an outstanding performance this year, placing sixth overall and netting two gold medals and four silver. Last year they were ecstatic when Alex Gunning gave them their ever first perfect score; this year they were beyond words to place so highly, and have everyone in the team on silver and above, another first for them. Alex Gunning was in fourth place overall, with a total score of 36.

The 2015 IMO team, after the closing ceremony. Back, from left to right: Martin Luk, Prince Michael Balanay, Xuzhi Zhang, Miles Yee-Cheng Lee, George Han. Crouching: Kevin Shen.

Impressions

Accompanying the team again this year were May Meng (King's College) as team manager, Malcolm Granville (Harvard University) as deputy leader, and me as team leader. As usual we left New Zealand a few days before the start of the jury meetings, on 30th June, so we could acclimate and spend some time in pre-IMO training in the week leading up to the competition. I'm sure the staff at our hotel thought we were crazy: here we were, having come all the way to Thailand, only to spend all our time working and barely leave the hotel! Nevertheless we did manage to take a break one evening to visit a night market, and I also slipped out one morning for a walk around the old city while the team were sitting a mock exam. It was hot and humid, and one of the first challenges was figuring out how to cross the very busy roads! Scooters were the clear favourite as the local form of transport, vastly outnumbering the cars and many of them carrying two people. I even saw a family of four with two young kids, all on the one scooter. The old city, surrounded by a moat and sections of a crumbling ancient wall, was full of Buddhist temples. Many dated back to the 14th century, and were in various states of repair, but were all awe-inspiring.

The IMO proper began for me on July 4th, and leaving the team to continue training with Malcolm I left to attend the jury meetings to select the problems for the contest. An extra day had been scheduled for the meetings this year, and somehow the discussion expanded to fill the available time, leading to some long days and nights in the jury room. I once again served as the secretary of the English Language Committee, which formulates the final English versions of the selected problems — used as the basis for the translations into all the other languages — and this year also chaired the jury session in which these were presented for approval.

The opening ceremony took place on July 9th, in the presence of Her Royal Highness Princess Chakri Sirindhorn. Royal time being at a premium, this was one of the shortest and most efficient opening ceremonies ever, lasting just 45 minutes, including the "parade of teams" — except that we all had to be there well over an hour beforehand! So there was quite a bit of waiting for the princess to arrive. To enter the hall we all had to go through both security and a "health check", which seemed to just involve reading our temperature off our foreheads. I think I may have failed this the first time — they looked dissatisfied with the result, and reached for another instrument — but second time lucky they looked happy, stuck a yellow dot on my collar and let me in. Her Highness's presence meant photos of the opening ceremony weren't permitted, but she otherwise seemed fairly down to earth, and gave a good speech about the importance of mathematics.

The first day of contest took place the next day, and included the following problem, solved by 265 of the 577 contestants, including four members of our team:

> **IMO 2015 Problem 1.** We say that a finite set $\mathscr{S}$ of points in the plane is *balanced* if for any two distinct points A and B in $\mathscr{S}$, there is a point C in $\mathscr{S}$ such that $AC = BC$. We say that $\mathscr{S}$ is *centre-free* if for any three distinct points A, B and C in $\mathscr{S}$, there is no point P in $\mathscr{S}$ such that $PA = PB = PC$.
>
> (a) Show that for all integers $n \geq 3$, there exists a balanced set consisting of n points.

(b) Determine all integers $n \geq 3$ for which there exists a balanced centre-free set consisting of n points.

Those of you more inclined to number theory might like to tackle problem two, solved by just 31 contestants:

IMO 2015 Problem 2. Determine all triples (a,b,c) of positive integers such that each of the numbers

$$ab-c, \quad bc-a, \quad ca-b$$

is a power of 2.

(*A power of* 2 *is an integer of the form* 2^n*, where* n *is a non-negative integer.*)

Miles correctly handled the case where $a = b$, earning one point on this problem under the mark scheme.

That afternoon the jury were taken on an excursion to a nearby elephant park, where we got to ride an elephant and then travel down a river on a bamboo raft. Shortly after we got there the news came through that a disaster had occurred: a small number of deputy leaders had accidentally been given the day two paper that morning by mistake. The IMO advisory board rushed back to the city to assess the situation, while the rest of us stayed on and did our best to enjoy the excursion, anticipating that we'd likely have to draw up a new day two paper on our return.

Sure enough, there was an emergency jury meeting as soon as we got back to the hotel that evening, and it was quickly decided that a new paper was needed. The advisory board, together with the problem selection committee, had prepared two possible options, and after some discussion and dissent — some leaders thought we should start again from scratch — one of these was adopted. Netherlands, Norway and I then skipped dinner to make a start on preparing the English language formulation. After some input from Australia and other English speaking leaders this was put to the jury and approved by 8pm, and by 11pm the translations into the other 55 languages had been prepared and approved. In the end it wasn't quite as painful as I'd anticipated, but nevertheless not something I'd like to have to do again! And in all likelihood contributed to this year's paper being harder than usual.

Fortunately there was no more drama after that, and the rest of the IMO went smoothly. An extra half day had also been allowed for co-ordination (marking), but Denmark, Slovenia and I all finished before that and were able to slip away for a hike up nearby peak Doi Pui, overlooking Chiang Mai. We then rejoined the other leaders in the afternoon at an excursion to the beautiful golden temple Wat Phrathat Doi Suthep, on the lower slopes of the mountain. The final jury meeting took place that evening, to decide the medal cuts. This year a new procedure was trialled, where we were presented only with the numbers of students that would receive each award, and not the actual scores themselves. This was intended to decrease the number of leaders arguing we should be "generous" with the medal cuts, out of self interest. It will probably take a few more trials to see how well this works. The only cut where there was any room for debate this year was that for gold, and the usual arguments for generosity resurfaced, with perhaps even more leaders arguing for the lower cut out of fear their students might be on the borderline. In the end the higher of the two possibilities was chosen by a narrow margin. At the closing ceremony the next day we were treated to a fantastic dance and drum performance and a wonderful banquet, and then once again the IMO was over and we were on our way home.

Our 2015 IMO medalists Xuzhi Zhang (left) and Miles Yee-Cheng Lee.

Our thanks go the Royal Society of New Zealand, Science OlympiaNZ, and the New Zealand Mathematics Enrichment Trust for their support. The problems and full results of the IMO can be found at imo-official.org, and photos and videos from IMO can be found at https://www.facebook.com/IMO2015ChiangMaiThailand and https://www.youtube.com/user/IMO2015Thailand.

Christopher Tuffley

MINZ 2015

More than 100 of New Zealand's mathematical scientists met in Auckland in late June and early July to use mathematics and statistics to solve industry problems. A week-long workshop was held as a way for companies to pitch their problems to people from around the region who then worked collaboratively to generate practical solutions through modelling, statistical analysis or computation.

Companies attending the event included white-ware manufacturer Fisher and Paykel who wanted to optimize the operation of their clothes dryer, fresh produce packing company Compac Sorting wanting a solution to a calibration issue with their spectroscopic systems, and start-up crime prevention company Eyedentify needing to improve their crime prevention algorithms. Others in attendance presenting problem challenges were dairy giant Fonterra, national grid operator Transpower, and farm management group Livestock Improvement Corporation. For more see http://www.minz.org.nz.

Event organizer Professor Emeritus Graeme Wake says the first workshop was a success with the teams reporting excellent progress at the end of the week. "More work will be required to complete the solutions but follow-on discussions are already being planned", Professor Wake says. "The collaborative groups transform how industries see and approach problems. It's a fast, effective and productive avenue for them to use. Further the large number of postgraduate students present had hands-on experience of handling industry and community based problems using mathematics and statistics."

Other contributors to the workshops include the NZ Mathematical Society, Callaghan Innovation, the ANZ Industrial and Applied Mathematics Group, KiwiNet, Te Pūnaha Matatini (a Centre of Research Excellence in Complex Systems and Networks), ANZ Industrial and Applied Mathematics group andthe Mathematical Sciences Group of AUT University.

Coverage from the week-long event is in various media. KiwiNet, who partnered running the event with Massey University, provided short videos on Youtube, see https://www.youtube.com/channel/UCBdlFHZ1WA4kiy3WQABUGjA. Also providers like Callaghan Innovation have posted blogs, see https://callaghaninnovation.wordpress.com/2015/07/15/reaching-critical-maths/.

Pictured are the invited speakers (except Professor Shaun Hendy, University of Auckland who was absent at the time), from left: Dr Maria Bruna (University of Oxford, UK), Professor Emeritus Graeme Wake (Director of the event), Hon. Ruth Richardson (Chair of KiwiNET) who opened MINZ-SG, and Dr Boris Baeumer (Chair of the NZ Branch of ANZIAM and University of Otago).

The following students received financial assistance from NZMS to attend: Gordon Hiscott (University of Otago), Jie Kuanj (University of Canterbury), Muhammed Tufail (Massey University PN), Alex van Brunt (Victoria University), Raziyeh Zarredogha, (Massey University PN).

NZMS NOTICES

NZMS Colloquium, University of Canterbury, Dec 1-3 2015

We are pleased to announce that registration is now open for this year?s NZMS Colloquium. The Colloquium will be held the University of Canterbury, December 1-3 2015, with arrival and a welcome reception on the evening of Monday November 30. Full details, including registration, invited speakers and local organising committee, are on the website: nzmathsoc.org.nz/colloquium2015/.

NZMS Student Travel Grants

One of the main activities of the NZMS is providing financial support to postgraduate students in mathematics in New Zealand. Towards this aim, the Society invites applications for Student Travel Grants from students to support them presenting their research at conferences, attending workshops, and developing new collaborations.

Students wishing to apply for a grant towards travel that will occur in the first half of 2016 must apply by 24 November 2015 for full consideration. Retrospective applications are not considered. Please note that the next deadline for applications is slightly earlier than usual, due to the timing of the Colloquium.

Further information about the Student Travel Grants is available on our website http://nzmathsoc.org.nz/?assistance. The current version of the application form is available at nzmathsoc.org.nz/downloads/applications/NZMS_FundingApplication_2015.pdf.

Call for nominations for NZMS Council positions

Nominations are called for Councillors on the New Zealand Mathematical Society Council. The term of office of a Council member is three years. Council members may hold office for two (but no more than two) consecutive terms. Existing Councillors may be nominated for the position of Incoming Vice-President. Nominations should be put forward by two proposers. The nominee and the two proposers should be current Ordinary members (including Student members) or Honorary members of the New Zealand Mathematical Society. The nominations, including the nominees consent, should be forwarded by 3 November 2015 to the NZMS Secretary, preferably by email. If nominations are sent by email, the two proposers and the nominee should each send separate email messages to the NZMS Secretary.

Notice of 2015 Annual General Meeting

The Annual General Meeting of the New Zealand Mathematical Society will be held on Tuesday 1st of December, at 5pm, during the New Zealand Mathematics Colloquium, at the University of Canterbury. Items for the Agenda should be forwarded by Friday the 20th of November to the NZMS Secretary, Emily Harvey.

GENERAL NOTICES

Centre of Excellence

Te Pūnaha Matatini is a new TEC-funded Centre of Research Excellence that uses data analytics and methods from complex systems to solve problems for business and to develop better economic and environmental policies. Te Pūnaha Matatini quite literally translates as the “meeting place for many faces”, a name that we like because it reflects the many disciplines – from mathematics to economics to anthropology – that are brought together by the Centre. Matatini – many faces – is also a metaphor for complexity in Te Reo Māori, and again this reflects the way that when people interact, complex phenomena can arise.

Te Pūnaha Matatini’s Director or Kaitohu is Shaun Hendy, a physicist and applied mathematician at the University of Auckland. The Deputy Directors are Andy Philpott, also from Auckland, and Alex James, from the

University of Canterbury. Te Pūnaha Matatini is hosted by the University of Auckland, where the Executive Manager – Te Kaiwhakahaere Matua – Kate Hannah, and Centre Coordinator or Whakahaere, Sarah Hikuroa, are based. At the moment Te Pūnaha Matatini has two dozen Principal Investigators and a dozen Associate Investigators from across the country. Our early career research network, Te Pūnaha Matatini Whānau, chaired by Rachelle Binny from the University of Canterbury, has around fifty members.

Our website (http://www.tepunahamatatini.ac.nz) contains a comprehensive list of our research projects, including a number of PhD scholarships and post-doctoral fellowships that are still being filled. These research projects span topics as diverse as the spread of infectious diseases like the flu through to whether the structure of the red meat industry is responsible for its inability to add value to its products. All of the problems we address involve mathematics, data analysis and empirical domain knowledge, which is why we've assembled such a multi-disciplinary team with the Centre.

We have had some success in seeking funding in addition to the initial TEC grant, so we do have the ability to grow our network of researchers. Anyone interested in joining the collaboration by becoming an Associate Investigator can write to the Director, Shaun Hendy (shaun.hendy@auckland.ac.nz), while early career researchers who might be interested in joining the Whānau can write to TPMWhanau@gmail.com. For news and updates follow us on twitter on @PunahaMatatini or @TPMWhanau.

Shaun Hendy
Director
Te Pūnaha Matatini

MISG reports available

There are spare (free) copies of the ANZIAM Mathematics-in-Industry Study Group Reports from 2004, 2005, and 2006 available. There were from the three meetings held in Auckland joint with Australia. If you want copies please contact the undersigned. They will then be mailed to you.

Graeme Wake
g.c.wake@massey.ac.nz

THE NEW ZEALAND MATHEMATICAL SOCIETY (Inc.)

APPLICATION FOR STUDENT TRAVEL GRANT

Name of Applicant: _____

Postal address: _____

_____

_____

_____

Email address: _____

Academic Affiliation and Current Program of Study: *(e.g. 2nd year of PhD in Mathematics at UC)*

_____

NZMS Status: Student member Yes / No Since (year): _____

Attached supporting information:

☐ Applicant statement ☐ Supervisor statement

☐ Budget (including quotes) ☐ Presentation details

Type of travel - circle (a) or (b):

(a) Conference or workshop attendance. Presentation: Talk / Poster / Both

Name of conference or workshop: _____

(b) Other research travel. Brief description (include details in supporting material):

_____

_____

Financial details: Total estimated cost: $ _____

Total being sought in this application: $ _____

List any previous support of this kind that you have received from the NZMS:

_____

_____

_____

Please read the application guidelines on the following page and sign the application.

The following supporting material is required:

- A statement (written by the applicant) outlining the nature of the activity for which the funds are being sought, and the benefit of the activity to the applicant's study/career. This statement is expected to include conference or workshop details (if applicable). (Up to 300 words.)
- A brief supporting statement from the applicant's supervisor outlining the relevance of the activity to your studies. (Up to 300 words.)
- A budget of total expected expenses, including supporting evidence (quotes) for any flights, accommodation, and registration fees that are included. NZMS student travel grants are not intended to cover the full costs of travel. Please outline other sources of assistance sought/approved to cover the remaining cost. (Note that NZMS expect students to choose thrifty travel and accommodation options. If you have included quotes for more expensive options, e.g. staying at hotels instead of hostels, please justify this. We do not cover subsistence costs.)
- The title, details (abstract), and status (*e.g.* proposed/accepted) of any oral and/or poster presentations.

Applications without **all** the supporting material will be returned and not considered.

Signature: _____ Date: ____/____/____

Please email your completed application, including the required supporting evidence, as **a single pdf file** to the NZMS secretary:

Dr Emily Harvey `e.p.harvey@massey.ac.nz`

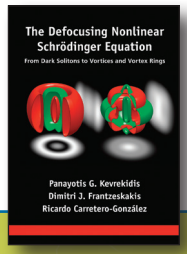
Eligibility:

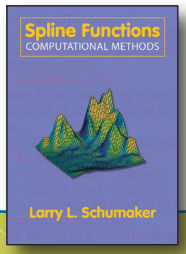
Students must be based at an institution in New Zealand and active within the New Zealand mathematical community. If possible, they should be presenting their work either as a talk or as a poster.

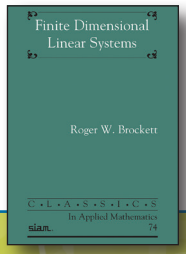
Applications must be made well in advance of travel (at least one month before departure, but the earlier the better). Retrospective applications will not be considered.

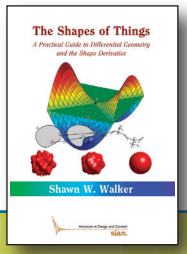
Applications are generally considered at the NZMS Council meetings mid-year (received by **1 June**) and at the Colloquium (received by **1 December**). If the travel you are applying for would occur before the next meeting of the NZMS Council, urgent applications may be considered between meetings. Please clearly state in the body of your email to the Secretary if your application is urgent.

New & Notable Titles









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P. G. Kevrekidis, D. J. Frantzeskakis, and R. Carretero-González

This is a broad study of nonlinear excitations in self-defocusing nonlinear media, summarizing state-of-the-art knowledge on the defocusing nonlinear Schrödinger-type models in a single volume. The book contains a wealth of resources, including over 800 references to relevant articles and monographs and a meticulous index for ease of navigation.

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978-1-611973-93-8 • List $98.00
SIAM Member $68.60 • OT143

Spline Functions: *Computational Methods*

Larry L. Schumaker

This book describes in detail the key algorithms needed for computing with spline functions and illustrates their use in solving several basic problems in numerical analysis, including function approximation, numerical quadrature, data fitting, and the numerical solution of PDEs. The focus is on computational methods for bivariate splines on triangulations in the plane and on the sphere, although both univariate and tensor-product splines are also discussed.

2015 • xii + 413 pages • Hardcover
978-1-611973-89-1 • List $83.00
SIAM Member $58.10 • OT142

Finite Dimensional Linear Systems

Roger W. Brockett

Originally published in 1970, this is a classic textbook that provides a solid foundation for learning about dynamical systems and encourages students to develop a reliable intuition for problem solving. It touches upon many of the standard topics in applied mathematics, develops the theory of linear systems in a systematic way, making as much use as possible of vector ideas, and contains a number of nontrivial examples and many exercises.

2015 • xvi + 244 pages • Softcover
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The Shapes of Things: *A Practical Guide to Differential Geometry and the Shape Derivative*

Shawn W. Walker

This self-contained overview of differential geometry explains how to differentiate a function (in the calculus sense) with respect to a "shape variable." This approach, which is useful for understanding mathematical models containing geometric partial differential equations, allows readers to obtain formulas for geometric quantities that are clearer than those usually offered in differential geometry texts.

2015 • x + 152 pages • Softcover
978-1-611973-95-2 • List $74.00
SIAM Member $51.80 • DC28

A Primer on Radial Basis Functions with Applications to the Geosciences

Bengt Fornberg and Natasha Flyer

Adapted from a series of lectures given by the authors, this monograph focuses on radial basis functions (RBFs), a powerful numerical methodology for solving PDEs to high accuracy in any number of dimensions. This method applies to problems across a wide range of PDEs arising in fluid mechanics, wave motions, astro- and geosciences, mathematical biology, and other areas, and has lately been shown to compete successfully against the very best previous approaches on some large benchmark problems. Using examples and heuristic explanations to comprise a practical and intuitive perspective, the authors address how, when, and why RBF-based methods work.

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Numerical Methods for Nonlinear Variational Problems

Roland Glowinski

This book addresses computational methods that have proven efficient for the solution of a large variety of nonlinear elliptic problems. These methods can be applied to many problems from science and engineering, but this book focuses on their application to problems from continuum mechanics and physics. Unlike other books on the topic, this one presents examples of the power and versatility of operator-splitting methods and provides a detailed introduction to alternating direction methods of multipliers and their applicability to the solution of nonlinear problems from science and engineering.

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