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Gazette

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- Reviews of books, particularly by Australian authors, or books of wide interest
- Classroom notes on presenting mathematics in an elegant way
- Items relevant to mathematics education
- Letters on relevant topical issues
- Information on conferences, particularly those held in Australasia and the region
- Information on recent major mathematical achievements
- Reports on the business and activities of the Society
- Staff changes and visitors in mathematics departments
- News of members of the Australian Mathematical Society

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Volume 47 Number 5 **2020**

The online version of this issue is available at
https://austms.org.au/publications/gazette/gazette475/

206 Editorial
David Yost

208 President's Column
Jacqui Ramagge

211 Letter to the Editors
James Franklin

212 Puzzle Corner 65
Peter M. Higgins

216 Prime Minister's Prize for Science

217 Where can I publish my educational research?
Deborah King and Greg Oates

221 Higher Degrees and Honours Bachelor Degrees in Mathematics and Statistics Completed in Australia in 2019
Peter Johnston

228 Obituary: Vaughan Jones
Arnaud Brothier, Pinhas Grossman, Scott Morrison and James Tener

232 Lift-Off Fellowship report:
Optimising oncolytic virotherapy treatment
Adrianne Jenner

239 Mathematical Research Institute MATRIX
Tom Keegan

241 SMRI News
Anthony Henderson

244 News

258 AustMS

Editorial

Sid and I welcome you to the December issue of the Gazette of the Australian Mathematical Society. Times remain challenging; let's begin with the bad news.

Vaughan Jones, the first antipodean to win a Fields Medal, passed away unexpectedly in September. It is not simple to do justice to his achievements, and to the gap now left in the mathematical landscape. Four of his many PhD students pay tribute to him in an obituary in this issue.

The economic impact of COVID was always likely to be greater than the health impact, and this is increasingly evident in many sectors. In particular, a number of voluntary redundancies in mathematics are reported in this issue. The profile of many of our departments is likely to be quite different in a few years.

Jacqui Ramagge presents her final column as President. She will step down at the Society's annual meeting in December, and Ole Warnaar will take over the position. We thank Jacqui for her contribution to the Society's governance over the last two years.

The Annual Meeting, like many conferences now, will be an entirely online event. We look forward to the resumption of face to face conferences, with all their possibilities for serendipitous interactions, perhaps from the middle of next year. Tom Keegan in his column from MATRIX calls for expressions of interest for future meetings at their centre in Creswick, and gives details of their online seminar series. The usual list of future conferences appears in the News section.

The list of international visitors there is the shortest it has ever been. Meanwhile, the report from the Sydney Mathematical Research Institute by Anthony Henderson announces details of the successful applicants for their International Visitor Program next year. Some of them are due to be in Australia as early as April 2021; we hope that the international health situation will permit these visits to go ahead.

Some good news is that Australian Research Council Discovery Project outcomes for 2021 have mostly been announced, and we list those in mathematics in the News section. This is a vast improvement over the procedure last year, when announcements of successful results stretched out over months for essentially political reasons. Eighteen grants remain undecided, having been referred to security agencies for clearance.

Another positive item is the award of the Prime Minister's Prize for Science to a group including AustMS member Professor Susan Scott, from the Australian National University.

If you are beginning to do educational research, have you wondered where to publish it? A communication from the Special Interest Group in Mathematics Education helps to answer this question.

Peter Johnston continues a valuable service by presenting his annual report on Higher Degrees and Honours Bachelor Degrees in Mathematics and Statistics completed in Australia. This important data set has been produced since 1993.

The Lift-Off Fellowship program continues to provide short term support for recent PhD graduates. Adrianne Jenner reports on her work applying mathematics to models of cancer growth and treatment.

A letter to the editor from James Franklin continues discussion of the topic "What is mathematics?".

Other regular features include the Puzzle Corner by Peter Higgins and news from the Society's Secretary, Deborah Jackson.

We wish you an interesting read of this issue of the Gazette and a safe and fruitful summer break.

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David Yost has lived in eight countries and ten cities. This has included working full-time at La Trobe University, the Australian National University, the Free University of Berlin, the University of Extremadura and King Saud University, as well as being a long-term visitor and sessional lecturer at several other institutions. He has been the recipient of a Queen Elizabeth II Fellowship, a Humboldt Fellowship and the Lester R Ford Award. He returned to Australia in 2003, to take a position in Ballarat, where he remains today. He served as Deputy Head of School for three years, Acting Director of the Centre for Informatics and Applied Optimization for two years, and was Director of the AustMS Annual Meeting in 2012. His random walk through mathematics has taken him from C*-algebras and approximation theory through Banach spaces to combinatorial geometry, optimisation and polytopes.

President's Column

Jacqui Ramagge*

This will be my last column as President, and I can't help feeling as if somewhere along the way we have lost a year but it has paradoxically taken 20 years to get through the lost year. I'm reminded of a series of books I used to read to the kids when they were small in which a child gets lost in this strange world and lives through great adventures trying to get home, but whenever he calls home it's only 5 minutes since he left and his mother reminds him to pick up some milk on his way home. Life is so surreal.

Australia managed to quash a second wave through the hard work of all Victorians. The threat of another outbreak in South Australia made it seem like a surreal game of SARS-CoV-2 whack-a-mole, made even more surreal by the discovery that the SA lockdown was triggered by an act of desperation. Even so, the numbers that are spurring Australians into action are nothing by comparison to what the UK is experiencing. In the third week in October there were over 9000 cases reported amongst students across 68 campuses in the UK. Just among students. Students have been isolating on and off in many universities for most of term. Part of the challenge was that students had been grouped into household bubbles to reduce transmission, but the households were quite large. This was a deliberate choice on behalf of universities so that students had a reasonable chance of forming social support networks. On the downside, it meant that when one student tested positive another 17 might be locked down with them. If one of the others showed symptoms during the 14-day isolation period and subsequently tested positive then the isolation clock would start again. This is clearly untenable, and we are piloting a regular testing protocol using lateral flow devices to run quick tests for the whole student population each week. I've recently ordered 65,000 tests to enable us to test the entire university twice in the run-up to the end of term so those who want to travel can do so safely. As I said, this is all very surreal and not at all what I would have expected to be doing right now.

What I would much rather be doing is travelling back to Australia to attend an Annual Meeting of the Society at the University of New England in Armidale in the week 7–11 December. Sadly, it seems that the decision some weeks ago to run the meeting online was a good call. On the bright side, I hear that we might be trying to replicate online the in-person experience of being able to mingle with colleagues that is such a valuable part of these meetings. I'm very much looking forward to catching up with many of you there. I'm less excited about the fact that I will be participating in the meeting from the UK rather than Australia. I sense that we're about to need a name for a new sort of jet-lag felt when you are still at home but adhering to a nocturnal lifestyle for the duration of a workshop or meeting that you are attending virtually. Perhaps it's a zone-lag. And I may

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find out how much of my jet-lag is due to the time difference and how much is due to the sheer exhaustion of travelling for days with very little sleep. This isn't quite what I envision when I think of life-long learning, but there is no doubt that it will be educational.

The Australian Research Council Discovery Project outcomes have almost been announced. It appears that only some grants have been announced and the rather wonderful interactive outcomes webpage has been reduced to a list of titles and summaries until the full outcomes are known. Apparently 18 grants have been referred to security agencies for clearance before a final decision is made. The grounds for doing so are not clear, and neither is the timescale for the final decision. It's not even clear which areas the projects are in as it is possible that the reason for referral is related to collaborating institutions as well as project content. This is the second year in a row in which Discovery Projects have been announced in batches. The reason for the delay this year is better than last year, when announcements were made by government MPs even in constituencies held by members of other parties. Perhaps next year the vetting that is now taking place can start earlier given that telling us in advance that certain things might trigger a security review would presumably be a security risk in itself. Who knows, perhaps some of the grants being held back are not really suspicious at all and are only delayed to make it harder to identify the reason for suspicion. Or perhaps having been in lockdown on my own for over half a year is finally getting to me.

It is good to see that Tim Marchant has been appointed Director of the Australian Mathematical Sciences Institute (AMSI). Over the last 18 years, AMSI has provided a focus for Australian Mathematics that has led to significant achievements. This year Australian academia has been debilitated by covid-19 and the government's reaction to it. Perhaps unsurprisingly, the moment in which institutions most need the advocacy that AMSI can provide is the time when they can least afford the financial cost of membership. I hope that university finances are sufficiently strong to enable continued membership and that AMSI can continue to advocate on behalf of the mathematical sciences.

The Society also needs to think carefully about the future. Issues that have been simmering in the background, such as the nature of publishing, have been pushed further into the foreground as the world has suddenly taken a sharp turn towards the digital. Open access publishing will force publishers to rethink their business models. Much of our income to date has come from our journals, and it is not clear how long that will last. We will have to decide not only how we want to run our suite of journals, but also how we might raise revenue in the future. I would therefore remind colleagues again that sustaining membership is available and encourage as many of you as are able to become sustaining members of the Society.

I would like to take the opportunity to thank all those who have helped and supported me over the last two years. I want to thank Deborah Jackson and Lilia Ferrario who replaced the irreplaceable Peter Stacey and Algy Howe as Secretary and Treasurer respectively. I want to thank Ole Warnaar who will take over the mantle of President at the forthcoming AustMS meeting for being flexible around

the distribution of responsibilities between the President and the President elect and enabling me to continue in the role while overseas this year. I want to thank Geoff Prince for having taken on so many jobs in his role as elected Vice-President and having done them so professionally. I don't think that role has ever been more active or effective! I want to thank May Truong for keeping everything running like clockwork. Last, but not least, I would like to thank Sid Morris and Eileen Dallwitz at the Gazette for their infinite patience at times when I surely did not deserve it.

I think it is fair to say that I will never forget this year. Like many others, I wish the year had played out slightly differently, and I am sorry that I did not get more done on behalf of the Society. Then I remind myself that, in times like these, having survived is an achievement in itself.

Live long and prosper 🖖

Jacqui Ramagge is a Fellow of the Australian Mathematical Society with research interests across algebra, analysis, and geometry. She is currently Executive Dean of the Faculty of Science at Durham University in the UK.

Jacqui has won awards for: teaching from the University of Newcastle; research environment from the University of Wollongong; and contributions to mathematics enrichment from the Australian Mathematics Trust. She has served on various Australian Research Council panels including as Chair of the Australian Laureates Selection Advisory Committee.

Letters to the Editors

In his letter in issue 47(4) Keith Tognetti suggests as the definition of mathematics, "The science of patterns" (as such).

That is comprehensible and fits a lot of mathematics, but has two disadvantages as a complete definition. First, "pattern" is undefined (and while we do roughly have an intuition of what patterns are, it is a rather vague one). Secondly, it does not easily fit the cases of (elementary) mathematics that fall under the once-popular definition that mathematics is "the science of quantity". It is a stretch to say that "2 is bigger than 1" is about patterns.

In my book *An Aristotelian Realist Philosophy of Mathematics* (2014) I argued that mathematics is "the science of quantity and structure". Structure, which is much the same thing as pattern, then needs a definition. I suggest that the study of structure means the study of purely structural properties, and a property is purely structural if it can be defined solely in terms of mereology (parthood) and logic.

Exercise: Show that symmetry is a purely structural property.

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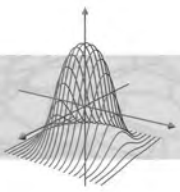

Puzzle Corner

Peter M. Higgins*

Welcome to Puzzle Corner 65 of the Gazette of the Australian Mathematical Society. In this first section I will introduce "Sequences and series and more series". After that I will give a solution to Puzzle Corner 64 on "Remainder Shortcuts".

I would be happy to receive your solutions to Puzzle Corner 65 not later than 30 January 2021. The email address for solutions is austmspuzzles@gmail.com. Any particularly interesting solutions will be mentioned in the next Puzzle Corner.

Sequences and series and more series

One source of despair for teachers of mathematical analysis is when a student keeps confusing the convergence of a series with convergence of the underlying sequence of terms. I mean, you can't get anywhere until you have the story straight on that one. This does lead to an interesting question however. A series is the sequence of partial sums of a given sequence. What is the sequence which results from acting that operation m times over? The precise problem is this one.

Problem. Let $S_0 = (a_n)_{n\geq 1}$ be a sequence of real or complex numbers and let S_1 be the corresponding sequence of partial sums, so that the nth term of S_1 is $s_{1,n} = \sum_{k=1}^{n} a_k$. Let $S_{m+1} = (s_{m+1,n})_{n\geq 1}$ $(m \geq 0)$ be the sequence of partial sums of S_m so that

$$s_{m+1,n} = \sum_{k=1}^{n} s_{m,k}.$$

Express $s_{m,n}$ in terms of m, n, and the members of the sequence S_0.

Remainder Shortcut Problem and Solutions

Remainder Problem

Perhaps one of the reasons the Remainder theorem looks a bit mysterious is that it seems only to apply to division by linear factors but that is not the case. Dividing one polynomial $p(x)$ by another $a(x)$ of degree n say, yields an equation of the form $p(x) = a(x)q(x) + r(x)$ where the remainder polynomial $r(x)$ is of degree less than n. If we know the roots of $a(x)$ we may substitute them into this equation to get linear equations in the coefficients of $r(x)$ and thereby find $r(x)$ without resorting to long division. Today I invite you to try this out on $p(x) = x^6 + 2x^5 - x^4 + 6x + 5$ for the following quadratic divisors $a(x) = \cdots$.

Problem 1.

$$\text{(i) } x^2 + x - 2, \quad \text{(ii) } x^2 + 1, \quad \text{(iii) } 4x^2 - 4x + 1.$$

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Problem 2. But it's not really about roots and for divisors of degree greater than 2, explicit factorization is often not even possible. With that in mind, with the same $p(x)$ as before, find the remainder for the divisors $a(x) = \cdots$

$$\text{(i) } x^2 - x - 1, \quad \text{(ii) } x^3 - x^2 + x - 2$$

by substituting for x^n in $p(x)$ through use of the equation $a(x) = 0$. And explain why that works.

Solutions

In response to the Remainder Shortcut Problem we received a solution to problem 2 from Dr Graham Baird. (Thanks to Alex Bishop for composing a draft of the combined solutions.) We combine our solutions with Dr Baird's as follows.

Problem 1. Our dividend polynomial for all our problems is $p(x) = x^6 + 2x^5 - x^4 + 6x + 5$. Let us write $r(x) = ax + b$.

(i) We have $a(x) = x^2 + x - 2 = (x+2)(x-1)$ which gives us the roots $t_1 = -2$ and $t_2 = 1$. Since for any root t of $a(x)$ we have $p(t) = r(t)$, we obtain the two equations

$$-23 = p(t_1) = r(t_1) = -2a + b \quad \text{and} \quad 13 = p(t_2) = r(t_2) = a + b.$$

From this we find that $a = 12$ and $b = 1$, and thus, $r(x) = 12x + 1$.

(ii) In this case, the roots are $\pm i$, but we only need one:

$$8i + 3 = i^6 + 2i^5 - i^4 + 6i + 5 = p(i) = r(i) = ai + b.$$

From this we see that $ai + b = 8i + 3$, and thus, $r(x) = 8x + 3$.

(iii) In this case the divisor has a repeated root $t = 1/2$, that is,

$$4x^2 - 4x + 1 = 4(x^2 - x + 1/4) = 4(x - 1/2)^2.$$

It follows then that t is also a root of the derivative $a'(x)$, from which we see that $p'(t) = r'(t)$. This yields the second equation that we need. Notice that $p'(x) = 6x^5 + 10x^4 - 4x^3 + 6$ and $r'(x) = a$. We obtain:

$$p\left(\frac{1}{2}\right) = \frac{1}{2^6} + \frac{2}{2^5} - \frac{1}{2^4} + 6\left(\frac{1}{2}\right) + 5 = \frac{513}{64} = r\left(\frac{1}{2}\right) = \frac{a}{2} + b;$$

and

$$p'\left(\frac{1}{2}\right) = \frac{6}{2^5} + \frac{10}{2^4} - \frac{4}{2^3} + 6 = \frac{101}{16} = r'\left(\frac{1}{2}\right) = a.$$

From this we find that

$$a = \frac{101}{16} \quad \text{and} \quad b = \frac{513}{64} - \frac{101}{32} = \frac{311}{64},$$

and thus

$$r(x) = \frac{101}{16}x + \frac{311}{64}.$$

Problem 2. To simplify our solution, we use the following notation. Let $a(x)$ be a polynomial of degree n, then we say that two polynomials $p(x)$ and $r(x)$ are equivalent modulo $a(x)$, denoted

$$p(x) \equiv r(x) \bmod a(x),$$

if there is a polynomial $q(x)$ such that $p(x) = a(x)q(x) + r(x)$. It can be verified that (similar to congruence relations over $\mathbb{Z}$) this equivalence relation preserves multiplication and addition. This means that if $x^n \equiv s(x) \bmod a(x)$ and $p(x) \equiv r(x) \bmod a(x)$, then we may replace each x^n in $p(x)$ with $s(x)$, and the congruence $p(x) \equiv r(x) \bmod a(x)$ will still hold.

Dr Baird began by writing the polynomial $a(x)$ as $a(x) = c_n x^n - b(x)$ where $b(x)$ is a polynomial of degree less than n. We then see that $c_n x^n \equiv b(x) \bmod a(x)$, and further, $x^n \equiv b(x)/c_n \bmod a(x)$. If $p(x)$ is of degree $m > n$ and

$$p(x) \equiv r(x) \bmod a(x),$$

then after replacing each x^n with $b(x)/c_n$, we obtain a polynomial $\overline{p}(x)$ of degree at most $m - 1 < m$ such that

$$\overline{p}(x) \equiv r(x) \bmod a(x).$$

Repeating this process, by induction we eventually obtain a polynomial $s(x)$ of degree less than n such that

$$s(x) \equiv r(x) \bmod a(x).$$

Dr Baird then showed that if there are polynomials $s(x)$ and $r(x)$ of degree less than n (the degree of $a(x)$) and $s(x) \equiv r(x) \bmod a(x)$, then $s(x) = r(x)$. This can be seen as if $s(x) \equiv r(x) \bmod a(x)$, then there must exist a polynomial $w(x)$ such that $r(x) - s(x) = a(x)w(x)$. Since $r(x) - s(x)$ is a polynomial of degree less than n, we find that $w(x) = 0$ and so $s(x) = r(x)$. Thus, we may obtain the remainder $r(x)$ by repeatedly replacing x^n in $p(x)$ with the polynomial $b(x)/c_n$. As an example of this process, consider the following.

(i) Let $a(x) = x^2 - x - 1$, then we may find $r(x)$ by repeatedly replacing x^2 with $x + 1$. Interestingly, we may show inductively that this process eventually replaces each x^k, where $k \geqslant 2$, with $f_k x + f_{k-1}$ where f_k is the k-th Fibonacci number. We then find that

$$\begin{aligned} p(x) &= x^6 + 2x^5 - x^4 + 6x + 5 \\ &\equiv (f_6 x + f_5) + 2(f_5 x + f_4) - (f_4 x + f_3) + 6x + 5 \bmod a(x) \\ &\equiv (f_6 + 2f_5 - f_4 + 6)x + (f_5 + 2f_4 - f_3 + 5) \bmod a(x). \end{aligned}$$

Using the known values $f_1 = f_2 = 1$, $f_3 = 2$, $f_4 = 3$, $f_5 = 5$ and $f_6 = 8$, we find that

$$p(x) \equiv 21x + 14 \bmod a(x)$$

and thus $r(x) = 21x + 14$.

(ii) Let $a(x) = x^3 - x^2 + x - 2$, then we may find the remainder by repeatedly replacing x^3 with $x^2 - x + 2$. Dr Baird performed this computation as

$$\begin{aligned} p(x) &= x^6 + 2x^5 - x^4 + 6x + 5 \\ &\equiv (x^3)^2 + 2x^2x^3 + 6x + 5 \bmod a(x) \\ &\equiv (x^2 - x + 2)^2 + 2x^2(x^2 - x + 2) + 6x + 5 \bmod a(x) \\ &\equiv 3x^4 - 5x^3 + 10x^2 + 9 \bmod a(x) \\ &\equiv 3x(x^3) - 5(x^3) + 10x^2 + 9 \bmod a(x) \\ &\equiv 3x(x^2 - x + 2) - 5(x^2 - x + 2) + 10x^2 + 9 \bmod a(x) \\ &\equiv 3x^3 + 2x^2 + 11x - 1 \bmod a(x) \\ &\equiv 3(x^2 - x + 2) + 2x^2 + 11x - 1 \bmod a(x) \\ &\equiv 5x^2 + 8x + 5 \bmod a(x), \end{aligned}$$

and thus $r(x) = 5x^2 + 8x + 5$.

Peter Higgins is a Professor of Mathematics at the University of Essex. He is the inventor of Circular Sudoku, a puzzle type that has featured in many newspapers, magazines, books, and computer games all over the world. He has written extensively on the subject of mathematics and won the 2013 Premio Peano Prize in Turin for the best book published about mathematics in Italian in 2012. Originally from Australia, Peter has lived in Colchester, England with his wife and four children since 1990.

Communications

Prime Minister's Prize for Science

Congratulations to AustMS member Professor Susan Scott, from the Australian National University, on being a co-recipient of the 2020 Prime Minister's Prize for Science. Susan is also a member of ANZIAM, ANZAMP and WIMSIG.

Fellow recipients of this award are Professor David McClelland (Australian National University), Emeritus Prof David Blair (University of Western Australia), and Professor Peter Veitch (University of Adelaide). Together they constitute the ARC Centre of Excellence for Gravitational Wave Discovery (OzGrav). The prize was awarded for their critical contributions leading to the first direct detection of a gravitational wave.

Another recent honour for Susan is her selection this year as a Fellow of the American Physical Society.

Where can I publish my educational research?

Deborah King* and Greg Oates**

One question we are often asked by colleagues new to educational research is, where do I publish my results? It is an important question whose answer depends on the type of paper being considered. In this article, we will briefly describe the different types of papers being written in tertiary mathematics education and the journals and conference proceedings that are appropriate choices in each case.

Tertiary mathematics education is a rather general term that encompasses a broad range of studies. These include local projects that report on a single classroom intervention, longitudinal studies at a single institution, projects that compare student responses across multiple institutions and papers that deal with education policy.

Ultimately, where you publish your paper generally depends on the type of contribution you are making to an existing body of knowledge. For example, is the paper reporting on a research study in the commonly accepted sense (does the study follow standard conventions of research with a theoretical perspective, a specific research question and a methodology that supports it); or is it more a report on innovative practice, with some data to support its effectiveness? If the former, then it may well be suitable for an international journal, if the latter a conference paper, or the classroom notes section that some journals provide maybe more suitable. One question that is helpful to keep in mind when you are choosing a journal to submit your paper to is, are my results telling the community something new? This is almost certainly required for acceptance by an international journal. Consulting the reference list of the papers you are including in your literature review to see the kinds of journals they appear in will give you a good guide as to whether or not your paper is suitable for a particular journal. You can also gain useful information from most journals' homepages, with respect to the aims and scope of the journal and the types of studies they accept. Reading some recent articles they have published can give you a good sense of the journal's style and purpose and help you gauge whether your article is a suitable fit.

Three examples of journals which publish research-specific studies in tertiary education are the *International Journal of Research in Undergraduate Mathematics Education* (IJRUME, https://www.springer.com/journal/40753), the *International Journal of Mathematical Education in Science and Technology* (IJMEST, https://www.tandfonline.com/toc/tmes20/current) and *Teaching Mathematics and its Applications* (TMA, https://academic.oup.com/teamat). IJRUME, as its name suggests, is dedicated to post-secondary mathematics education research. It welcomes original papers of an empirical, theoretical, and methodological focus on the learning and teaching of mathematics at undergraduate and graduate levels, as

*Chair, Special Interest Group in Mathematics Education
**Member of the Committee, Special Interest Group in Mathematics Education

well as research commentaries on current and important issues in the field. IJMEST is not specific to the undergraduate level, but most articles are certainly at the upper levels of secondary education, transitioning into undergraduate mathematics. One of its underlying goals is the presentation of an interdisciplinary approach so that one professional group may benefit from the experience of others. TMA provides a forum for the exchange of ideas and experiences which contribute to the improvement of mathematics teaching and learning for students from upper secondary/high school level through to university first degree level. A distinctive feature of the journal is its emphasis on the applications of mathematics and mathematical modelling within the context of mathematics education world-wide. Its research section of papers, similar to IJRUME, invites contributions based on empirical investigation and/or theoretical argument whose conclusions inform the improvement of mathematics teaching and learning at the relevant level.

As with any research area, the higher ranked the journal in mathematics education, the more difficult it will be to have a paper accepted. If you are aiming for a top journal, your research will need to be of broad interest with sound research methodology and statistical analysis. You can gain some idea of the rankings of the more prominent journals in mathematics education in the article by Williams and Leatham (2017) titled 'Journal quality in mathematics education' (https://www.nctm.org/Publications/Journal-for-Research-in-Mathematics-Education/2017/Vol48/Issue4/Assessing-Journal-Quality-in-Mathematics-Education/). They list and compare 20 of the top English-language journals that exclusively or extensively publish mathematics education research (from 2008 to 2014), to help inform authors, editors, and evaluators in their efforts to publish and recognize quality research in mathematics education. However, this list is not specific to the tertiary sector, and it also does not include IJRUME, whose first volume was published only in 2015.

Peer-reviewed conference proceedings can be a good place to submit your first paper, for papers that either report on innovative practice, or perhaps present the early stages of a formal research study in order to seek feedback. Some journals also publish practical teaching-based papers under sections called *Classroom Notes* or similar (for example IJMEST and TMA). TMA describes its papers in its second section as articles based on scholarly argument, informed by knowledge of research, such as innovative approaches to teaching with a justification for considering their wider use. Papers accepted in conference proceedings tend to be shorter than journal articles (up to 10 pages) and often report on findings from a case-study at a single institution. So, for example, if you have incorporated a well-known intervention like a *flipped classroom* (http://www.deltaconference.org/papers.php) in your teaching, this may be a good paper for conference proceedings provided the results add something new to the literature.

If your results deal with a known topic and do no more than confirm results already published elsewhere, then the paper is unlikely to be published. However, your results may still be accepted as a talk at a conference, which can be used to gain audience insights and strengthen the opportunities for later publication. Submitting an abstract for the *Special Interest Group in Mathematics Education* (SIGME,

https://austms.org.au/special-interest-groups/special-interest-group-in-mathematics-education/) at the annual Australian Mathematical Society (AustMS) conference, or a paper for the annual *Mathematics Education Research Group of Australasia* (MERGA, https://merga.net.au/) conference, which also includes tertiary mathematics education as one of its components, can be a good place to start.

Three conferences that focus specifically on mathematics education at the tertiary level and publish papers in their own proceedings are:

- DELTA (http://www.deltaconference.org/), the biennial Southern Hemisphere conference on the teaching and learning of undergraduate mathematics and statistics, held in Australia, New Zealand, South Africa and South America on a rotational basis;
- Research in Undergraduate Mathematics (RUME, http://sigmaa.maa.org/rume/Site/About.html), an annual conference held in the USA as a *Special Interest Group* of the *Mathematical Association of America*(MAA, https://www.maa.org/);
- INDRUM (https://indrum2020.sciencesconf.org/), a biennial European forum which began in 2016, under the auspices of the International Network for Didactic Research in University Mathematics.

Other mathematics education conferences and international fora that include tertiary mathematics as significant components, for instance as a *Special Interest Group* or a *Topic Study Group*, include the annual *International Group for the Psychology of Mathematics Education* (PME, http://www.igpme.org/); the annual Joint Mathematics Meetings (JMM, http://jointmathematicsmeetings.org/meetings/national/jmm2021/2247_intro) of the *American Mathematical Society* (AMS) and the *Mathematics Association of America* (MAA); and the four-yearly *International Congress on Mathematical Education* (ICME, https://www.mathunion.org/icmi/conferences/icme-international-congress-mathematical-education), under the auspices of the International Commission on Mathematical Instruction (ICMI, https://www.mathunion.org/icmi).

Some conferences publish special editions of international journals in addition to their conference proceedings. IJMEST, https://www.tandfonline.com/action/journalInformation?show=specialIssues&journalCode=tmes20, for example, has published a special edition of the DELTA proceedings since 2005, on a wide range of topics ranging from the teaching of specific content (e.g. from the 2019 conference held in Perth, Ponce Campuzano's consideration of *The use of phase portraits to visualize and investigate isolated singular points of complex functions* (https://www.tandfonline.com/doi/full/10.1080/0020739X.2019.1656829)), and Stewart et al.'s reflections on teaching eigentheory, entitled *Leading students towards the formal world of mathematical thinking: a mathematician's reflections on teaching eigentheory* (https://www.tandfonline.com/doi/full/10.1080/0020739X.2019.1657598), through to such pedagogical considerations as learning support programmes for first-year mathematics (Poh and Kahn, 2019, https://www.tandfonline.com/doi/full/10.1080/0020739X.2019.1656830), and the previously raised flipped classroom (Naccarato and Karakok, 2015, http://www.deltaconference.org/papers.php). Papers accepted for these special editions are normally of the same quality as those accepted in the regular journal editions but may deal with a

narrower topic that is specific to the conference. The advantage of choosing a special edition for your paper is that the publication time is usually quite short, the conference audience is likely to be interested in your work and can thus provide feedback you might not gain from a regular journal publication. Studies suitable for special editions include those that present results from innovations that are emerging or new to the literature or significant studies that track changes over years or compare results across institutions. Papers in special editions can motivate further research on a topic within the conference community.

If you intend to submit a paper for publication in any journal or conference proceedings, the study it reports on will need to be well-designed, clearly documented and grounded in the literature. Don't be afraid to aim high even if it's your first submission. If your paper is not accepted, you will still receive valuable constructive feedback for future publications and can submit the current paper to a lower-tier journal. Take a chance, you have nothing to lose!

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Higher Degrees and Honours Bachelor Degrees in Mathematics and Statistics Completed in Australia in 2019

Peter Johnston*

This report presents data relating to students who completed Honours or Higher Degrees in Mathematics during 2019. The data are part of an on-going project for the Australian Mathematical Society and should be read in conjunction with previous reports [1]–[20] covering the period 1993–2018.

Appendix 1 presents data for students completing Honours degrees in 2019, at all Universities in Australia. Within each institution, the data are broken down into male and female students and into the three traditional areas of Mathematics: Pure; Applied, and Statistics. There is also the general category "Mathematics" for institutions that do not differentiate between the conventional areas. Finally, there is an "Other" category for newer areas of mathematics such as Financial Mathematics. Each category is further broken down into grades of Honours awarded. Appendix 2 presents the coursework masters degrees (with classifications) awarded by the University of Melbourne in 2019. In the discussions that follow, these data have been merged together and will be referred to simply as "Honours". Appendices 1 and 2 combined show that in 2019 there were 204 Honours completions in Australia, with 126 (62%) receiving First Class Honours (compared with 128 out of 184 (70%) in 2018 and 113 out of 171 (66%) in 2017). Over recent years the average fraction of First Class degrees awarded has been about 65%.

Figure 1 presents the total number of students completing Honours degrees in Mathematics, including two year Coursework Masters degrees (with classifications) over the period 1959–2019. It shows that in 2019 the number of Honours completions has again increased over the previous two years and there is now a higher number of completions than in the years prior to that. The figure also shows the numbers of male and female students who completed Honours over the same time period. Last year, there was again a reasonably large increase in the number of male students with 163 completions (compared to 136 in 2018 and 127 in 2017), with the number of female students decreasing slightly, down to 41 (compared to 48 in 2018 and 44 in 2017). It is interesting to observe from this figure that, while the overall trend in the number of Honours completions over the past 10 years is increasing, this increase comes from an upward trend in the number of male student completions. Perhaps somewhat disturbing is the observation that the number of female student completions over that period is more-or-less static.

Appendix 3 presents the data for Higher Degree completions in 2019. The data are broken down into traditional Coursework Masters, Research Masters and PhD degrees, with the latter two divided into the three typical areas of Mathematics.

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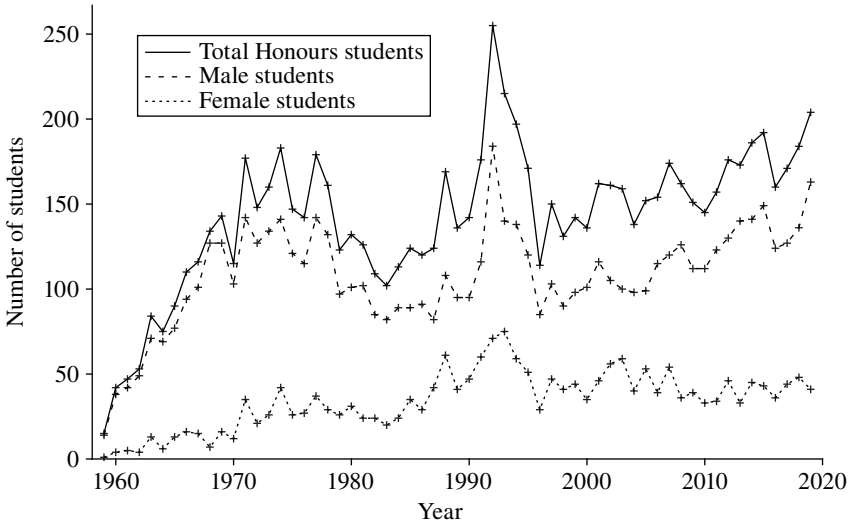

Figure 1. Number of Honours degrees, including two year Coursework Masters degrees (with classifications), completed in Mathematics and Statistics, 1959–2019.

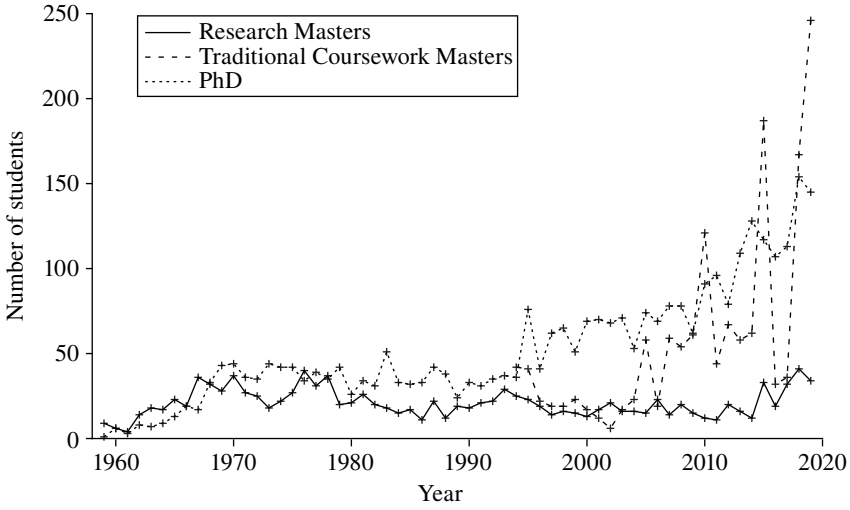

Figure 2. Number of research higher degrees completed in Mathematics and Statistics, 1959–2019.

These data are also represented in Figure 2, as part of the overall Higher Degree data for the period 1959–2019. The figure shows that:

1. There was a slight decrease in the number of PhD completions compared with 2018, but there is still an overall increasing trend over the past 20 years. In 2019, there were 145 PhD completions (compared with 154 in 2018 and 113 in 2017), of which 100 were by male students and 45 by female students. This shows a small drop in the number of completions by male students

(108 in 2018), while the number of completions by female students remained steady (45 in 2018).

2. The number of Research Masters completions (34) decreased slightly, down from 41 in 2018 but is the second largest number of completions in recent years.
3. The number of traditional coursework masters completions again increased massively with 246 completions in 2019, compared to 167 in 2018 and 36 in 2017, which is much larger than the previous record of 187 completions from 2015.

This year represents the ninth occasion that data have been reported for two year coursework masters degrees with classifications (similar to existing Honours degrees). These degrees make up 30% of the overall Honours-type degrees awarded in Australia in 2019. The University of Melbourne is the only university to offer such degrees in place of the traditional Honours degree, although some other universities are expected to follow this model. As time goes on, and more universities offer coursework masters degrees of this type, the two data sets will be differentiated and displayed as separated entities (backdated to 2011).

For those who are interested in the finer details, the raw data are available directly from me. Simply send me an e-mail. I have an Excel spreadsheet containing the complete data for 2019 as well as spreadsheets containing cumulative data from 1959 for Honours, Research Masters and PhD degrees.

I would like to thank the many people who took the time and effort to collect this data and forward it to me. This year I received 30 out of a possible 38 responses to requests for data, which is similar to last year's response rate, but down from the number of responses received in recent years. Finally, if having read this report, you would like to contribute missing data for 2019, I would be happy to add it to the spreadsheet.

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Appendix 1. Number of Honours degrees completed in Mathematics and Statistics, 2019

Uni.	Sex	Maths			Pure			Applied			Statistics			Other			Honours
		I	IIA	IIB	III	I	IIA	IIB	III	I	IIA	IIB	III	I	IIA	IIB	III	Total
ACU	M																	0
	F																	0
ADF	M																	0
	F																	0
ANU	M	11																11
	F	3																3
BOU																		0
																		0
CDU																		0
																		0
CQU	M																	0
	F																	0
CSU	M																	0
	F																	0
CUT																		0
																		0
DKU	M																	0
	F																	0
ECU	M																	0
	F																	0
FDU	M									1								1
	F																	0
FED	M																	0
	F																	0

Appendix 1. (Continued.)

Uni.	Sex	Maths I	Maths IIA	Maths IIB	Maths III	Pure I	Pure IIA	Pure IIB	Pure III	Applied I	Applied IIA	Applied IIB	Applied III	Statistics I	Statistics IIA	Statistics IIB	Statistics III	Other I	Other IIA	Other IIB	Other III	Honours Total
GFU	M																					0
	F																					0
JCU																						0
																						0
LTU	M																					0
	F																					0
MDU	M										1			2								3
	F																					0
MNU	M					5	2	1		2	1			1								12
	F					1																1
MQU	M																					0
	F																					0
QUT	M	4	1	1																		6
	F		1																			1
RMT	M									1												1
	F														1							1
SCU	M																					0
	F																					0
SUT	M																					0
	F																					0
UAD	M										1				2			3				6
	F													1								1
UCB																						0
																						0
UNC																						0
																						0
UNE	M									1												1
	F																					0
UNS	M					5				4	2	1	1	7	5	1		1	2	1		30
	F					1					1											2
UQL	M					6	1			1					1							9
	F						1			1												2
USA	M									1												1
	F																					0
USN	M					4	2			8	2			3								19
	F					1				2												3
USQ	M																					0
	F													1								1
UTM																						0
																						0
UTS	M					1				1												2
	F																					0
UWA	M					4				2				3				1				10
	F					1					1			1								3
UWG	M					2					1			1	1			6				11
	F					1												1				2
UWS	M																					0
	F																					0
VUT																						0
																						0
Totals		18	2	1	0	32	6	1	0	24	11	1	1	20	10	1	0	12	2	1	0	143

Appendix 2. Number of two year coursework masters degrees (with classifications) completed in Mathematics and Statistics, 2019

Uni.	Sex	Pure				Applied				Statistics				Other				Total
		I	IIA	IIB	III	I	IIA	IIB	III	I	IIA	IIB	III	I	IIA	IIB	III	
UMB	M	3	3	2		3		2		5	2	6	4	6	1	1	3	40
	F					1		1		1	4	3	6	1	1		3	21
Totals		3	2	2	0	4	0	3	0	6	6	9	10	7	2	1	6	61

Appendix 3. Number of research higher degrees completed in Mathematics and Statistics, 2019

Uni.	Sex	Course-work Masters	Research Masters				Research Masters Total	PhD				PhD Total
			Pure	Appl	Statist	Other		Pure	Appl	Statist	Other	
ACU	M						0					0
	F						0					0
ADF	M						0		1			1
	F			1	1		2		2			2
ANU	M	8					0	1	4			5
	F	5					0	1				1
BOU							0					0
							0					0
CDU							0					0
							0					0
CQU	M						0					0
	F						0					0
CSU	M						0					0
	F						0					0
CUT							0					0
							0					0
DKU	M						0					0
	F						0					0
ECU	M						0					0
	F						0					0
FDU	M	3					0	1				1
	F						0		2			2
FED	M						0			1		1
	F						0		1			1
GFU	M						0		1			1
	F						0					0
JCU							0					0
							0					0
LTU	M						0		1	4		5
	F						0			1		1
MDU	M						0			1		1
	F						0					0
MNU	M	13					0	2	5	1		8
	F	16					0	2				2
MQU	M		1		1		2	3		1		4
	F						0		1	1		2
QUT	M			1	3		4	1	3			4
	F				3		3			3		3
RMT	M	85					0					0
	F	33					0		2	4		6

Appendix 3. (Continued.)

Uni.	Sex	Course-work Masters	Research Masters Pure	Appl	Statist	Other	Research Masters Total	PhD Pure	Appl	Statist	Other	PhD Total
SCU	M						0		3	1		4
	F						0					0
SUT	M						0					0
	F						0		1			1
UAD	M		3	1	2		6	4	1			5
	F		1	2	2		5					0
UCB							0					0
							0					0
UMB	M						0	4	2	3	3	12
	F						0	1	2	2	2	7
UNC							0					0
							0					0
UNE	M	1					0	2				2
	F	1					0					0
UNS	M	16	2				2	5	2	4		11
	F	18					0		1	2		3
UQL	M	14		1		2	3	1	3	3	1	8
	F	16	2				2			2		2
USA	M						0		1			1
	F						0					0
USN	M						0	2	3	2		7
	F						0	1	4			5
USQ	M						0		3	1		4
	F						0		1			1
UTM							0					0
							0					0
UTS	M	9					0		1	2		3
	F	4					0	1				1
UWA	M		1	1	2		4	2	1	3		6
	F						0	1	1			2
UWG	M	1					0	2	4	1		7
	F	2					0	1	1			2
UWS	M	1			1		1					0
	F						0					0
VUT							0					0
							0					0
Totals		246	10	7	15	2	34	38	58	43	6	145

Vaughan Jones

31 December 1952 to 6 September 2020

Photo by courtesy of Akram Aldroubi of Vanderbilt University

Vaughan Jones, one of the world's outstanding mathematicians, passed away suddenly on 6 September 2020, at the age of 67. Born and raised in New Zealand, Jones was the first mathematician from the southern hemisphere to be awarded a Fields Medal. Known for an unconventional and informal style, he delivered his plenary lecture at the International Congress of Mathematicians in Kyoto in 1990 wearing an All Blacks rugby jersey.

Jones' primary field of research was the theory of operator algebras, a mathematical discipline initiated by John von Neumann in the early 20th century and inspired by the discovery of quantum mechanics. But he carved out his own distinctive path, cutting across a vast and diverse mathematical landscape. His pioneering work and extraordinary vision have had enormous influence on a wide range of different areas of mathematics and theoretical physics, from low-dimensional topology to quantum field theory. Longtime friend and colleague Roberto Longo likened Jones' unique mathematical style to that of a painter, producing incredibly beautiful and deep works of art with the simplicity of a great master.

Vaughan Frederick Randal Jones was born on 31 December 1952 in Gisborne, NZ. He was educated at St Peter's School in Cambridge, NZ and Auckland Grammar School. After undergraduate studies at the University of Auckland, he went to Switzerland where he completed a PhD at the University of Geneva under the supervision of André Haefliger and Alain Connes. He moved to the United States in 1980, where he held positions at the University of California, Los Angeles and the University of Pennsylvania, before arriving at the University of California, Berkeley. He was a Professor of Mathematics at Berkeley for 26 years. In 2011, he retired from Berkeley as Emeritus Professor and moved to Vanderbilt University as Stevenson Distinguished Professor of Mathematics, where he remained until his death.

In the 1980s, Jones initiated the theory of subfactors. A factor is a maximally noncommutative von Neumann algebra, i.e. one with trivial center. A subfactor is an embedding of one von Neumann algebra inside another. Subfactor theory is concerned with symmetries arising from such embeddings. In his PhD thesis, Jones had classified ways in which a finite group can act on a factor; such group actions give rise to subfactors of fixed points, whose symmetries reflect the acting groups. Motivated by an analogy with subgroups of groups, he then defined an index for arbitrary subfactors, and proved the surprising result that this index is "quantized" — only a discrete spectrum of values between 1 and 4 can be realized as the index of a subfactor (although all values above 4 are realized).

Jones is perhaps most widely known to general mathematical audiences for a knot invariant called the Jones polynomial. The classification of knotted strings in three-dimensional space is a fundamental problem in topology. The Jones polynomial is a powerful invariant that is able to distinguish between some knots that were not distinguished by earlier invariants such as the Alexander polynomial, which had been discovered in the 1920s. The Jones polynomial led to the resolution of several of the Tait conjectures from the 19th century, and has found modern applications as far afield as understanding the structure of knotted DNA strands.

What was particularly astonishing about the discovery of the Jones polynomial is that it emerged from the seemingly unrelated field of operator algebras. While proving the index theorem, Jones had found that the symmetries associated with subfactors give rise to certain algebraic relations first observed in the context of statistical mechanics. These relations appear similar to those satisfied by canonical generators of the braid group, which led Jones to construct new representations of the braid group. He then showed that a trace on these representations coming from the von Neumann algebra setting could be used to define a knot invariant.

The discovery of the Jones polynomial led to a surge of activity in a number of diverse research areas — including quantum groups, statistical mechanics, topological quantum field theory, and low-dimensional topology — and launched an entirely new field called quantum topology.

Aside from its applications to knots and mathematical physics, Jones' theory revealed intricate and beautiful internal symmetries of subfactor embeddings that have come to be known as "quantum symmetries" (following the analogy of subfactors with groups). For subfactors with small index – up to 4 – these symmetries are always related to groups or quantum groups. But in the 1990s new "exotic" quantum symmetries associated with subfactors with certain indices slightly larger than 4 were discovered. These mysterious quantum symmetries had not appeared in any other mathematical context, and therefore represent genuinely novel mathematical phenomena.

One of Jones' major projects in the late 1990s and early 2000s was his theory of planar algebras. Originally conceived as a topological axiomatization of the standard invariant of a subfactor, the notion of a planar algebra has found broader application as a concrete formalism for analysing the structure of pivotal categories, which play an important role in representation theory. As Terence Tao has written, "Traditional algebra notation is one-dimensional in

nature, with algebraic expressions being described by strings of mathematical symbols . . . Planar algebras, by contrast, fully exploit the topological nature of the plane . . . I found the mere possibility of higher dimensional notation being the natural choice for a given mathematical problem to be conceptually liberating."

When Jones first arrived in Geneva in 1974, he began studying physics, and only subsequently switched to mathematics for his PhD. But physical motivation remained a guiding constant throughout his career, and the ideas and insights flowed in both directions. His subfactor theory plays a foundational role in the conformal net approach to conformal field theory. More recently, subfactor theory has seen increasing connections with both conformal field theory and topological quantum computing, an approach to quantum computation pursued at Microsoft's Station Q by a group led by Fields Medallist topologist Michael Freedman.

In his later years, Jones frequently cited as inspiration the mathematical problem of determining whether every subfactor arises from conformal field theory in some suitable sense. This problem is still open, and is being studied from different points of view by a number of his colleagues and students. While he did not solve the problem, in typical fashion Jones' inquiries led to a wealth of interesting and original mathematics, including new unitary representations of the famous Thompson's group – which in turn led to novel connections between Thompson's group and knot theory.

His remarkable career earned Jones numerous accolades and awards, in addition to the Fields Medal. He was inducted as a Fellow of the Royal Society in 1990 and as a member of the National Academy of Sciences in 1999. In an unusual honor for a mathematician, he was made Honorary Vice President for Life of the International Guild of Knot Tyers in 1992. He was designated a Knight Companion of the New Zealand Order of Merit in 2009. In 2010 the Royal Society Te Apārangi established the Jones Medal in his honor.

He also held numerous positions of leadership in the discipline, including Vice President of the American Mathematical Society and Vice President of the International Mathematical Union. He had a lifelong commitment to supporting mathematics in New Zealand, and was principal founder and leader of the New Zealand Mathematics Research Institute (NZMRI).

Jones also had close connections to Australia. Elected as a Corresponding Fellow of the Australian Academy of Science in 1992, he visited Australia a number of times, including most recently in 2019 for the workshop Subfactors in Sydney at UNSW. Australian mathematicians were regularly featured in the annual NZMRI summer schools for graduate students that Jones organized. Four of his former PhD students now work in Australia, on a range of topics including higher category theory, conformal field theory, subfactor theory, and representations of Thompson's group – reflecting Jones' broad research interests.

Vaughan was a colleague, mentor, and friend to countless mathematicians around the world, including more than 30 PhD students over the course of his career. A humble, kind, and down-to-earth person with a great sense of humor, Vaughan was never one to stand on ceremony. He was remarkably approachable for such a

formidable figure, and was always particularly gracious in his support of students and junior researchers.

As his former students, we benefited from and were inspired by his generosity with his time and ideas, as well as his encouragement in developing our independent research directions. A highlight of our PhD years was Vaughan's subfactor seminar at Berkeley, later at Vanderbilt, where the freewheeling exchange of ideas made for an exhilarating experience. Vaughan set the tone, never shy about challenging a speaker or asking for additional explanation, with the resulting interaction invariably elevating the discussion.

Vaughan's generosity and excitement in sharing mathematical discovery was a hallmark of his research style. As longtime friend and colleague David Evans noted, since the beginning of his career, Vaughan was known in the mathematics community for an "openness in sharing ideas through every stage of development from speculation and conjecture of the way forward to discussing and explaining results" – an unusually inclusive approach in the sometimes competitive world of academic research. His brilliance, charisma, and magnanimity formed a high tide which lifted all who were fortunate to be in his mathematical orbit. And his many mathematical and professional collaborations often turned into close and lasting friendships.

Vaughan was a person of diverse interests who enjoyed life. His many outdoor pursuits included playing rugby in his youth, skiing (which is how he met his wife Wendy in Geneva), playing tennis with his family, and golfing in courses around the world in his later years. He was an avid windsurfer and later kitesurfer, which often led him to coordinate his travel schedule with the sea and the wind. He had a lifelong involvement in music and singing, and performed for many years in the orchestra at UC Berkeley commencement ceremonies. He was passionate about good coffee, and seemed more proud of his Certificate of Barista Skills than of his Fields Medal.

His students fondly remember and treasure the post seminar beer-and-pizza nights at Raleigh's Pub in Berkeley; weekends at Vaughan's Bodega Bay vacation home ("The Bodega Bay Institute of Mathematics"); summer conferences in Maui and in Vaughan's native New Zealand; and numerous conferences and research programs around the world, the last of which was the 2020 MSRI semester program Quantum Symmetries which Vaughan co-organized.

Vaughan is survived by his wife Martha (Wendy); children Bethany, Ian, and Alice; and grandchildren. He is greatly missed by his family, his many friends around the world, and his students and colleagues.

Arnaud Brothier (UNSW), a.brothier@unsw.edu.au
Pinhas Grossman (UNSW), p.grossman@unsw.edu.au
Scott Morrison (University of Sydney), scott@tqft.net
James Tener (ANU), james.tener@anu.edu.au

Lift-Off Fellowship report: Optimising oncolytic virotherapy treatment

Adrianne L. Jenner*, Supervisor: Peter S. Kim
Fellowship dates: 30 June to 30 October 2019
Host Institution: University of Sydney

Fellowship outcomes

Publications

1. Jenner, A.L., Frascoli, F., Yun, C-O. and Kim, P.S. (2020). Optimising hydrogel release profiles for viro-immunotherapy using oncolytic adenovirus expressing IL-12 and GM-CSF with immature dendritic cells. *Appl. Sci.* **10,** 2872.
2. Lee, T., Jenner, A.L., Kim, P.S. and Lee, J. (2020). Application of control theory in a delayed-infection and immune-evading oncolytic virotherapy. **17,** 2361–2383.

Continuing projects

1. Optimal combined TRAIL and oncolytic virus delivery protocol for Glioblastoma (submission early 2021)
2. Impact of stromal density on OV efficacy in Glioblastoma (submission early 2021)

Fellowship results summary

Introduction

Oncolytic virotherapy and immunotherapy are two promising fields in cancer therapeutics. Oncolytic viruses (OVs) are genetically engineered viruses that preferentially infect and lyse cancer cells. Many viruses have been investigated as potential OVs, including the Herpes Simplex Virus, vaccinia and adenovirus. OVs can be engineered to be immunotherapy agents through gene insertions which cause the production of immunostimulatory signals that stimulate an antitumour immune response. While extremely promising, combined OV and immunotherapy still has a significant way to go before a curative protocol is determined. In this fellowship, we developed and published two deterministic representations of experimental OVs for which we determined optimal treatment protocols, see Jenner *et al.* [1] and Lee *et al.* [2] or the brief descriptions below. In turn, as part of this fellowship we developed an agent-based model for glioblastoma, an aggressive brain cancer, and investigated the potential effectiveness of an oncolytic adenovirus modified to induce secretion of TNF-related apoptosis inducing ligand (TRAIL) [3]. This work

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is still ongoing, but it has inspired a spin-off collaborative project investigating the impact of stromal density on OV efficacy using *ex vivo* patient glioblastoma samples.

Optimising a hydrogel release profile for combined oncolytic virotherapy and immunotherapy

Sustained-release injectable gels have been replacing systemic administration of cancer therapies for some time. More recently, the use of hydrogels as an OV delivery system has been investigated. Oh *et al.* [4] loaded degradable hydrogels with oncolytic adenovirus genetically modified to express immunostimulatory cytokines interleukin-12 (IL-2) and granulocyte-macrophage colony-stimulating factor (GM-CSF). They showed that this delivery system was able to reduce the growth of Lewis Lung Carcinoma (LLC) tumours in mice. In addition, they found that co-delivery of the OV with naïve dendritic cells (DCs) was able to significantly inhibit tumour growth.

We developed a system of ODEs to represent the interaction between tumour cells, dendritic cells, antigen-presenting cells, helper T cells and cytotoxic T lymphocytes [1] (Figure 1(a)). Parameters in the model were fit hierarchically to Oh *et al.*'s time-series tumour measurements under different treatment protocols. We then investigated how different release profiles for the OV and DCs from the hydrogel would impact the efficacy. One profile we considered was a sigmoidal release profile (Figure 1(b)–(e)). For different underlying parameterisations of the sigmoidal release we obtained vastly different tumour burdens on day 20. Using a genetic algorithm, we then determined the optimal sigmoidal profile for the gel (see [1]).

Optimising a delayed-infection and immune evading oncolytic virus derivative

In previous work, we used a Voronoi Cell-based model to investigate a similar sustained-release concept where coating (e.g. with degradable alginate) would delay the initial infection of the OV whilst still allowing it to propagate into the tumour [5]. In this fellowship, we developed a PDE approximation of the Voronoi Cell-based model to further investigate this delayed-infection treatment and determine whether an optimal coating existed [2] (Figure 2(a)).

Using control theory, we first determined the optimal proportion p of the initial OV dosage that was coated, given different lengths of treatment duration T_f (Figure 2(b) and 2(c)). This was for the special case of homogeneous single coating density (i.e. $K = 1$). Unsurprisingly, after 5 days, there is a non-zero proportion of initial coated virus that is optimal. We then further considered the existence of K coating levels in the initial injection, where each coating level i is modelled explicitly (Figure 2(a)). We found that given sufficient options of coating densities, the optimal treatment required a very heterogeneous initial distribution of virus coating (Figure 2(d)). Overall, the optimisation implied that a non-intuitive mixture of high-coating levels ($K = 13$) and low-coating levels ($K = 0$, 3 and 4) are necessary to achieve a minimum tumour size.

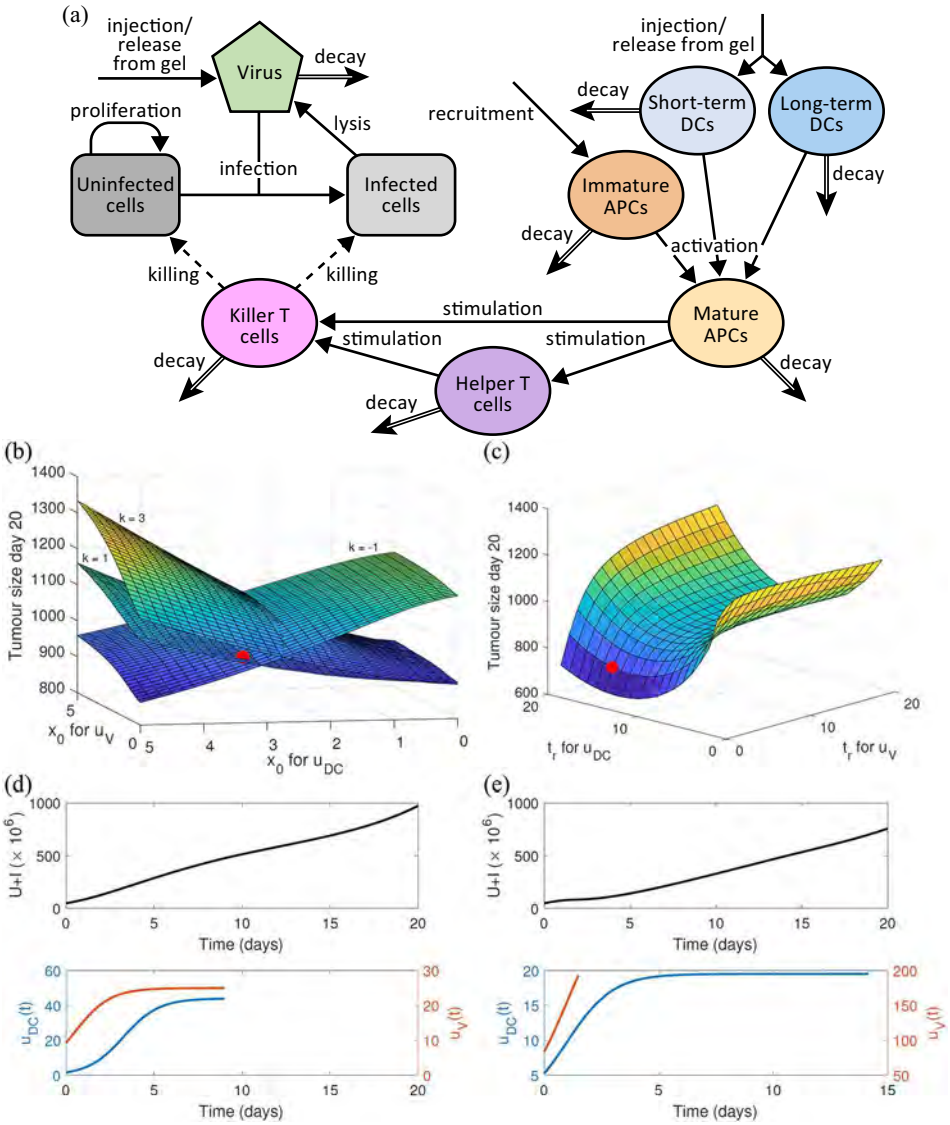

Figure 1. (a) Flow diagram for the tumour–OV-immune interaction from OV and DCs loaded onto a hydrogel. Short-lived and long-lived DCs (D_S and D_L) are released from the hydrogel at rate $u_{DC}(t)$ and OV (V) is released at a rate $u_V(t)$ Virus infects uninfected tumour cells (U) creating infected cells (I) which lyse to release new virions. DCs and immature APCs (A_I) become mature APCs (A_M) through infected cell recognition and then activate helper T cells (H) and CTLs (K). CTLs then induce apoptosis in infected cells. (b)–(e) Effectiveness of different sigmoidal gel-release rates. Tumour size at day 20 as a function of (b) varying midpoint x_0 for virus and DCs with duration of release $t_r = 9$ and planes representing the sigmoidal steepness $k = -1, 1$ and 3, or (c) varying duration of release t_r. The red points in (b) and (c) correspond to the simulated release profiles in panels (d) and (e) for the number of tumour cells U + I and corresponding release profiles. Figures originally published in [3].

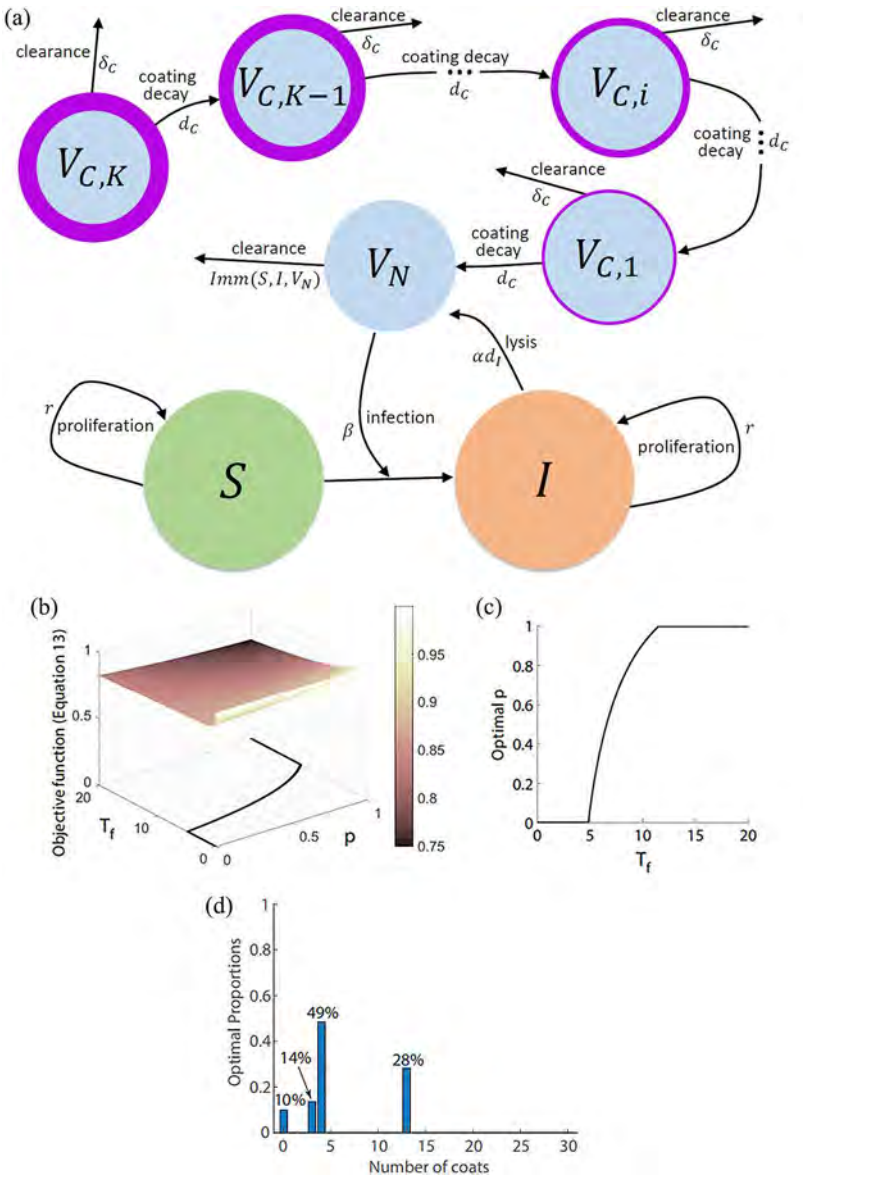

Figure 2. Flow diagram for the interaction between coated/uncoated virus and tumour cells. (a) An initial concentration of coated ($V_{C,i}$ for coating levels $i = 1 : K$) and uncoated virus (V_N) is injected into the system. The coating on the virus decays until the virus is completely uncoated. Uncoated virus infects susceptible cells (S), creating infected cells (I). These infected cells then undergo lysis dying and releasing new uncoated viruses into the system. (b) The value of the objective function (minimum tumour size at time T_f) for the proportion of the initial injection that is coated p, with $K = 1$. Solid lines in (b)–(c) show the value of the optimal p that minimises the objective function, with $K = 30$. (d) Optimal initial proportion of virus in each coating level i to achieve an integrated minimal tumour size. Figures originally published in Jenner *et al.* [2]

Continuing work: Optimal combined TRAIL and oncolytic virus delivery protocol for glioblastoma

Glioblastoma is an aggressive brain cancer which is incurable due to its resistance to conventional chemotherapy and radiotherapy. Recently, OVs have been considered as a way of bypassing the resistance of glioblastoma cells to conventional therapies. In this fellowship, we developed an agent-based representation in PhysiCell [6] for glioblastoma formation and treatment with an oncolytic adenovirus (Figure 3). In this model, we considered two types of glioblastoma tumour cells:

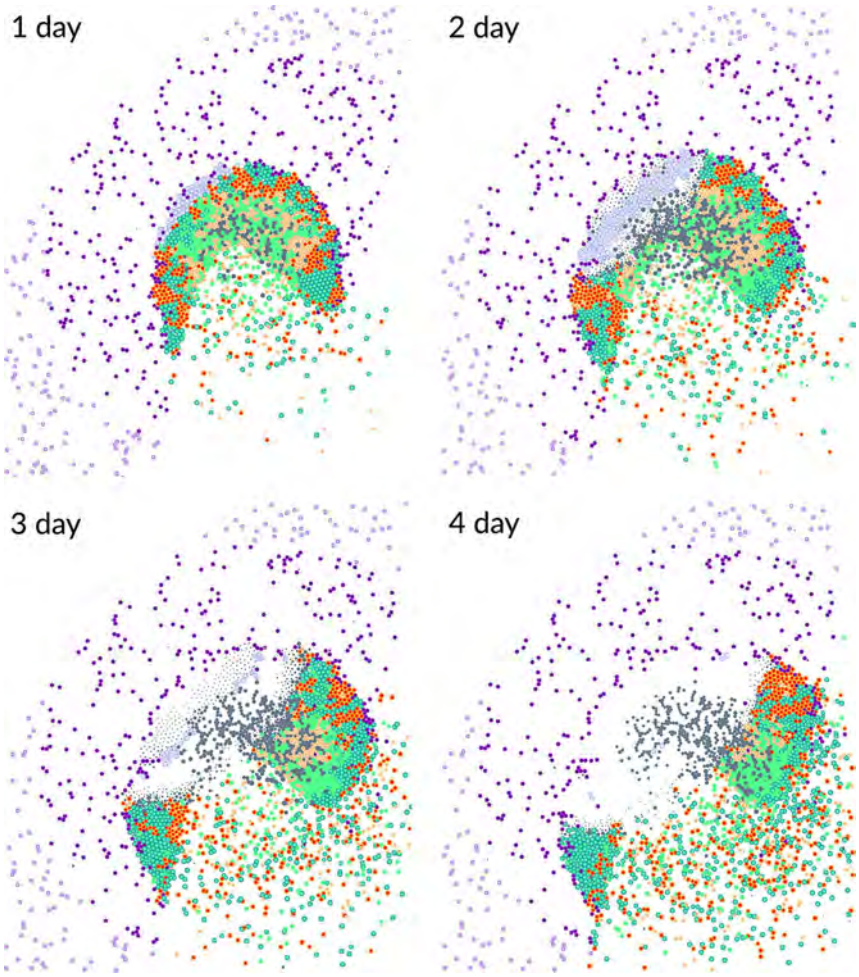

Figure 3. Time-evolution in PhysiCell of OV treatment of glioblastoma. Glioblastoma tumour cells (cancerous astrocytes in orange and glioma cells in green) are proliferating in a region of high- and low-density ECM. Regions of low-density ECM allow for cancerous cell migration. Astrocytes (light purple) become tumour associated astrocytes (dark purple) through the release of their corresponding paracrine by glioblastoma cells. OV infected cells are light blue.

cancerous astrocytes and glioma cells. In regions of high-density ECM, tumour cell movement is governed by cell-cell pressure and in low-density ECM regions their movement is Brownian motion. We simulated the diffusion of an OV through the tissue with the built in PhysiCell PDE equation [6] accounting for cell uptake and secretion of virus. A model was implemented for OV replication within glioblastoma cells, described using a set of ODEs. After the virus had sufficiently replicated, the cell would lyse releasing newly replicated OV and TRAIL.

At the moment, we are working to validate the model to experimental data for OV dynamics in glioblastomas. Following this, our goal is to further understand what dosage protocol is needed for the OV to optimise treatment.

References

[1] Jenner, A.L., Frascoli, F., Yun, C-O. and Kim, P.S. (2020). Optimising hydrogel release profiles for viro-immunotherapy using oncolytic adenovirus expressing IL-12 and GM-CSF with immature dendritic cells. *Appl. Sci.* **10,** 2872.

[2] Lee, T., Jenner, A.L., Kim, P.S. and Lee, J. (2020). Application of control theory in a delayed-infection and immune-evading oncolytic virotherapy. *Math. Biosci. Eng.* **17,** 2361–2383.

[3] Oh, E., Hong, J., Kwon, O-J. and Yun, C-O. (2018). A hypoxia-and telomerase-responsive oncolytic adenovirus expressing secretable trimeric TRAIL triggers tumour-specific apoptosis and promotes viral dispersion in TRAIL-resistant glioblastoma. *Sci. Rep.* **8,** pp. -1-13.

[4] Oh, E., Oh, J-E., Hong, J., Chung, Y., Lee, Y., Park, K.D., Kim, S. and Yun, C-O. (2017). Optimized biodegradable polymeric reservoir-mediated local and sustained co-delivery of dendritic cells and oncolytic adenovirus co-expressing {IL}-12 and {GM}-{CSF} for cancer immunotherapy. *J. Control. Release* **259,** 115–127.

[5] Jenner, A.L., Frascoli, F., Coster, A.C.F. and Kim, P.S. (2020). Enhancing oncolytic virotherapy: observations from a Voronoi cell-based model. *J. Theor. Biol.* https://doi.org/10.1016/j.jtbi.2019.110052.

[6] Ghaffarizadeh, A., Heiland, R., Friedman, S.H., Mumenthaler, S.M. and Macklin, P. (2018). PhysiCell: An open source physics-based cell simulator for 3-D multicellular systems. *PLoS Comput. Biol.* **14,** e1005991.

Dr Adrianne Jenner has a background in applied mathematics focusing on models of cancer growth and treatment. In 2013, she received a Bachelor of Mathematics from the University of Wollongong, and in 2015 obtained First Class Honours for a Bachelor of Science (Applied Mathematics), at the University of Sydney. Following this, she completed her PhD thesis in 2019 at the University of Sydney in mathematical biology. Currently, she is a postdoctoral Fellow at the Université de Montréal and Centre hospitalier universitaire (CHU) Sainte-Justine, Montréal, Canada, supervised by Dr Morgan Craig under a Postdoctoral Fellowship from the Fonds de recherche du Quebec (Quebec research fund). The focus of her postdoctoral research is in developing new mathematical and computational techniques to understand novel cancer therapeutics and optimise treatment outcome. More recently, her research has been focused on developing computational and mathematical representations of the immune response to SARS-CoV-2 infection.

MATRIX

Tom Keegan*

Call for Research Programs

Anyone can apply to organise a MATRIX research program. Every research program should have ample unstructured time to encourage collaborative research. Longer programs can have an embedded conference or lecture series. Short workshops focusing on a special theme are also welcome. The MATRIX Family Fund provides additional support to participants with families.

The MATRIX Scientific Committee selects programs on scientific excellence as well as on the participation rate of high-profile international participants and/or business and industry partners, among other criteria.

The next deadline for research program proposals in 2023-2024 will be on Friday, 16 April 2021. Expressions of interest (EOI) may be submitted at any time. Guidelines can be found at https://www.matrix-inst.org.au/guidelines/.

Research Program Organisers are encouraged to supplement their funding from MATRIX through other schemes including the: International Visitor Program of the University of Sydney Mathematical Research Institute; AMSI and AustMS/ ANZIAM workshop funding scheme; and AustMS travel grants. https://www.matrix-inst.org.au/funding-opportunities/

PhD Student Online Research Symposia

MATRIX recently invited PhD students in the mathematical sciences around Australia to submit EOIs to design and run their own online research symposium. The focus is on exchanging ideas, collaborating and building relationships with their peers.

A number of exciting EOIs have been received for consideration by the MATRIX Scientific Committee, and we are looking forward to hosting upcoming online PhD student research symposia in the near future. https://www.matrix-inst.org.au/events-01/phd-student-symposia/

Upcoming Research Programs

Eight programs scheduled for 2020 were postponed due to Covid-19 and have been rescheduled for 2021.

We look forward to hosting 15 research programs in 2021.

*MATRIX, Creswick, http://www.matrix-inst.org.au/

Online Seminar Series

MATRIX hosts a series of monthly online seminars. You are invited to join us.

Our upcoming seminar speaker is:

- Javier Tordable, CTO Office, Google Cloud, 3 December 2020

For information on future seminars and access to recordings of past seminars, visit https://www.matrix-inst.org.au/events-01/online-seminars/.

Past MATRIX online seminars in 2020:

- Peter Bühlmann, ETH Zürich
- Akshay Venkatesh, Institute of Advanced Study (IAS),
  Dedekind Sums, Lattice Point Counting, and K_2
- Miranda Chih-Ning Cheng, University of Amsterdam,
  Modular Forms and Applications
- Geordie Williamson, University of Sydney,
  Modular Representation Theory and Geometry
- Michael I. Jordan, University of California Berkeley (UCB),
  Optimization with Momentum
- Maria Chudnovsky, Princeton University,
  Holes with Hats and the Erdös-Hajnal conjecture
- James McCaw, University of Melbourne,
  Mathematical Modelling of Infectious Diseases
- Terry Tao, University of California Los Angeles (UCLA),
  The Collatz Conjecture

Further Information

Comments, suggestions and requests are always welcome. Please send these, as appropriate, to:

Director:	Jan de Gier (jdg@matrix-inst.org.au)
Deputy Directors:	David Wood (davidw@matrix-inst.org.au) Peter Bouwknegt (peterb@matrix-inst.org.au)
Executive Officer:	Tom Keegan (tomk@matrix-inst.org.au)
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Website: https://www.matrix-inst.org.au
Twitter: https://twitter.com/MATRIX_Inst

Tom Keegan is the Executive Officer of MATRIX. He has worked in research and graduate research management in the university sector in Victoria for the past 16 years. He provides expertise in managing high-level strategic initiatives, resources and operational planning for MATRIX. Tom is a member of the Australasian Research Management Society (ARMS) and former member of the ARMS Victoria-Tasmania Chapter Executive. https://www.linkedin.com/in/tomkeegan2/

The Sydney Mathematical Research Institute

Anthony Henderson*

While many of the challenges of this year remain, spring has brought a new optimism to our much-sanitized institute in the University of Sydney Quadrangle. In especially pleasing news, SMRI Director Geordie Williamson was one of the finalists for the 2020 Eureka Prizes in the category of Leadership in Innovation and Science. This year's awards ceremony on 24 November had to be held online, at some cost to its customary glamour. Nevertheless, this was very welcome recognition of Geordie's excellence in research and his dedication to inspiring and advancing the nation through the work of SMRI.

As I write in mid-October, we are eagerly awaiting the first of our official SMRI domestic visiting researchers and looking forward to the time (at some point in 2021, hopefully) when we will host international visitors again. I am happy to announce below the latest batch of 16 successful applicants to our International Visitor Program, whose research ranges widely over the mathematical sciences. Of course, the travel dates of these visitors are even more tentative than usual.

In this round of the program, pandemic-related funding constraints appear to have limited the number of applications involving other Australian universities, so we hope that future rounds can return to a more usual mix. We expect to concentrate on domestic visits for the next few months and will open another round of the International Visitor Program in 2021 when the prospects for international travel are better defined. For the latest, please check our website https://mathematical-research-institute.sydney.edu.au.

International Visitor Program – August 2020 round
Successful Applicants[1]

Sydney Mathematical Research Institute acknowledges the valuable contributions (financial and otherwise) to the International Visitor Program made by the School of Mathematics and Statistics at the University of Sydney and by the hosts and universities listed below.

Sheehan Olver (Imperial College London)
Research interests: Spectral methods, orthogonal polynomials, complex analysis
Dates: 1 April – 15 May 2021 (University of Sydney, *Host:* Geoffrey Vasil)

*Sydney Mathematical Research Institute, University of Sydney.
Email: anthony.henderson@sydney.edu.au

[1]Dates are as of 13 October 2020 and are subject to change. For up-to-date information see the SMRI website.

Henri Guenancia (Paul Sabatier University)
Research interests: Complex algebraic and analytic geometry, canonical metrics in complex geometry
Dates: 5 April – 7 May 2021 (University of Sydney, *Host:* Behrouz Taji)

Christof Melcher (RWTH Aachen University)
Research interests: Partial differential equations, calculus of variations, mathematical physics, geometric analysis, stochastic differential equations
Dates: 17 May – 15 July 2021 (University of Sydney, *Host:* Beniamin Goldys)

Rafał Kulik (University of Ottawa)
Research interests: Time series, long memory, heavy tails, extreme value theory, empirical processes
Dates: 1 June – 31 July 2021 (University of Sydney, *Host:* Qiying Wang)

Erwan Rousseau (Aix-Marseille University)
Research interests: Complex algebraic and analytic geometry, Kobayashi hyperbolicity, holomorphic foliations
Dates: 1 June – 31 August 2021 (University of Sydney, *Host:* Behrouz Taji)

Mark Andrea de Cataldo (Stony Brook University, New York)
Research interests: Topology, Hodge and cycle theory of algebraic maps
Dates: 1 July – 15 October 2021 (University of Sydney, *Host:* Geordie Williamson)

Jana de Wiljes (University of Potsdam)
Research interests: Data assimilation, unsupervised learning, data analysis, inverse problems, uncertainty quantification
Dates: 2–31 August 2021 (University of Sydney, *Host:* Georg Gottwald)
1–21 September 2021 (University of Tasmania, *Host:* Terence O'Kane)
22 September – 13 October 2021 (Monash University, *Host:* Tiangang Cui)

Andrew Krause (University of Oxford)
Research interests: Mathematical biology, pattern formation, partial differential equations, dynamical systems
Dates: 2–31 August 2021 (University of Sydney, *Host:* Peter Kim)
1–14 September 2021 (Monash University, *Host:* Mark Flegg)

Francisco Crespo (University of Bío-Bío)
Research interests: Continuous dynamical systems, Hamiltonian dynamics, geometric mechanics, celestial mechanics
Dates: 2 August – 10 November 2021 (University of Sydney, *Host:* Holger Dullin)

Hans Boden (McMaster University)
Research interests: Low-dimensional topology, knots and links, invariants of knots and 3-manifolds, gauge theory, character varieties
Dates: 16 August – 9 October 2021 (University of Sydney, *Host:* Zsuzsanna Dancso)

Jonathan Kujawa (University of Oklahoma)
Research interests: Algebraic Lie theory, representation theory of Lie (super)-algebras and related structures, combinatorial, geometric, categorical methods in representation theory

Dates: 1 October – 30 November 2021
(University of Sydney, *Host:* Kevin Coulembier)

Paul Griffiths (Coventry University)
Research interests: Hydrodynamics, stability, non-Newtonian, boundary layer
Dates: 1 November – 1 December 2021 (University of Sydney, *Host:* Sharon Stephen)
2–8 December 2021
(Queensland University of Technology, *Host:* Michael Dallaston)

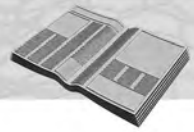
Ivan Angiono (National University of Córdoba)
Research interests: Quantum groups, Hopf algebras, tensor categories
Dates: 1 November – 15 December 2021
(University of Sydney, *Host:* Geordie Williamson)

Claudia Bucur (University of Milano-Bicocca)
Research interests: Partial and integro-differential equations, nonlocal operators, calculus of variations, geometric analysis
Dates: 1–31 October 2021
(The University of Western Australia, *Host:* Enrico Valdinoci)
1–21 November 2021 (MATRIX)
22 November – 20 December 2021 (University of Sydney, *Host:* Daniel Hauer)

Vladimir Kazakov (University of Paris)
Research interests: Theoretical and mathematical physics, quantum field theory, quantum and classical integrability, matrix models, theoretical statistical mechanics
Dates: 1–15 December 2021 (University of Sydney, *Host:* Alexander Molev)
16–31 December 2021 (Australian National University, *Host:* Vladimir Bazhanov)
5–15 January 2022 (The University of Melbourne, *Host:* Paul Zinn-Justin)

Martin Schmidt (University of Mannheim)
Research interests: Integrable systems, geometric analysis
Dates: 13 December 2021 – 5 February 2022
(University of Sydney, *Host:* Emma Carberry)

Anthony Henderson is currently the Executive Director of the University of Sydney Mathematical Research Institute, which he helped to establish in 2018. After obtaining his PhD from the Massachusetts Institute of Technology in 2001, he returned to the University of Sydney as a postdoctoral researcher and has worked there ever since. For his publications in geometric and combinatorial aspects of representation theory, Anthony was awarded the Christopher Heyde Medal in 2011 and the Australian Mathematical Society Medal in 2012. He also received a Faculty of Science Citation for Excellence in Teaching in 2009, and his Honours-level lecture notes on Lie algebras were published by Cambridge University Press in 2012. He is a founding Director of the Simon Marais Mathematics Competition for undergraduates in the Asia-Pacific region.



News

General News

Mathematics in the Media

The GiST (Girls in STEM) Toolkit, a project funded by the Australian Government's Department of Industry, Science, Energy and Resources, has produced a new video featuring Emeritus Professor Cheryl Praeger available at https://www.thegist.edu.au/students/women-in-stem/video-interviews/.
It is one of a series of videos profiling women in STEM, especially to encourage girls into STEM. Congratulations to Cheryl.

Special Issue on 'Multivariable Optimization by Intelligent and Numerical Modelling and Simulation'

Intelligent techniques have emerged in the last three decades as an nontraditional means to enrich numerical computation for complicated problems that were traditionally regarded as ill-defined problems in mathematical sciences. This Special Issue aims to solicit high-quality papers reporting latest applications of numerical and intelligent modelling and simulation for solving multivariable optimization problems in all disciplines.

Guest Editor: Professor William Guo, Central Queensland University
Web: https://www.mdpi.com/journal/mathematics/special_issues/Multivariable_Optimization_Intelligent_Numerical_Modelling_Simulation

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Completed PhDs

Australian National University

- Dr Daniel Nix, *The resolvent and Riesz transform on connected sums of manifolds with different asymptotic dimensions*, supervisors: Andrew Hassell, Adam Sikora, Thierry Coulhon and Pierre Portal.

Central Queensland University

- Dr Maen Zubaydi, *A study on consumer spending behaviour to improve business modelling strategy in the mobile app market*, supervisors: Ergun Gide and William Guo.

RMIT University

- Dr Saritha Kodikar, *Bayesian inference in ecological and epidemiological models*, supervisors: Lewi Stone, Haydar Demirhan and Yan Wang.

University of Melbourne (Melbourne Integrative Genomics & School of Mathematics and Statistics)

- Dr Ali Mahmoudi, *Inference under the coalescent with recombination*, supervisors: David Balding and Yao-ban Chan.

UNSW Sydney

- Dr Raveen De Silva, *Maximum generalised roundness of graph metric spaces*, supervisor: Ian Doust.
- Dr Haya Aldosari, *Asymptotic enumeration of sparse uniform hypergraphs, with applications*, supervisor: Catherine Greenhill.

University of Wollongong

- Dr Yu Ma, *Identification and prevention of value disclosure risk associated with noise-multiplied data and noise-infused tabular data, and using linkage error model to correct estimation bias of probabilistically-linked data*, supervisors: Yan-Xia Lin (UOW), James Chipperfield (Australian Bureau of Statistics) and Pavel Krivitsky (UOW).

Awards and other achievements

Australian National University

- Rodney Baxter received The Peter Baume Award at the 2020 Chancellor's and Vice Chancellor's Awards ceremony on Tuesday 17 November. The Peter Baume Award is the university's most prestigious award and recognises "eminent achievement and merit of the highest order".
- Lindon Roberts was recently awarded the 2019 Christopher Reddick Prize from the University of Oxford for his doctoral research "Derivative-free algorithms for nonlinear optimisation problems".
- Professor Brendan McKay and Dr Qing Wang have been awarded $407,167 for their discovery project *Deep learning for graph isomorphism: theories and applications*.
- Professor Murray Batchelor has been awarded $310,000 for the discovery project *Free parafermions: a challenge for non-Hermitian physics*.
- Dr Qiang Guang has been awarded $340,548 for the DECRA project *Minimal surfaces and singularities of mean curvature flow*.

James Cook University

- Dr Michael Meehan has been awarded $364,981 for the DECRA project *Advancing genomic-driven infectious diseases modelling*.

La Trobe University

- Dr Amanda Shaker (Deputy Director of Learning and Teaching School of Engineering and Mathematical Sciences) has become a FHEA (Fellow of

the Higher Education Academy). Moreover Amanda has received College of SHE Provost Early Career Teaching Award for 2020.
- Associate Professor Katherine Seaton (Department Director of Teaching and Learning; Course Coordinator for BSc/M Teach) has become a Senior Fellow of the Higher Education Academy (SFHEA) and a Fellow of the Australian Mathematical Society (FAustMS).
- Dr Yuri Nikolayevsky, Professor Holger Dullin (University of Sydney) and Professor Dr Vladimir Matveev (University of Jena) have been awarded $390,000 for their discovery project *Finite dimensional integrable systems and differential geometry.*

Macquarie University

- Dr Sophie Calabretto is among the finalists of the 2020 Australian Museum Eureka Prize, in the Promoting Understanding of Science category. She is recognised for her commitment to raising the profile of mathematics in Australia.

Monash University

- Professor Jessica Purcell and Dr Daniel Mathews have been awarded $355,000 for their discovery project *Connections in low-dimensional topology.*
- Associate Professor Jerome Droniou, Dr Tiangang Cui and Professor Santiago Badia, together with Professor Youssef Marzouk (Massachusetts Institute of Technology) and Dr Jesus Carrera (Barcelona), have been awarded $475,000 for their discovery project *Interface-aware numerical methods for stochastic inverse problems.*
- Dr Jessica Kasza and Professor Andrew Forbes, together with Professor Richard Hooper (Queen Mary University of London), Professor James Hughes (Fred Hutchinson Cancer Research Center, Seattle) and Dr Schadrac Agbla (London School of Hygiene and Tropical Medicine), have been awarded $420,000 for their discovery project *Increasing the efficiency and interpretability of stepped wedge trials.*
- Dr James Saunderson has been awarded $395,775 for the DECRA project *Realising the potential of hyperbolic programming.*

RMIT University

- Dr Sona Taheri presented a keynote speech entitled "Nonsmooth optimization models in machine learning" at the online "Workshop on Nonsmooth Optimization and its Applications" organized by Urmia University of Technology, Urmia, Iran, 16–17 September.

Swinburne University of Technology

- Ivan S. Maksymov and Andrey Pototsky were awarded the 2020 Ig Nobel Physics Prize at the Annual Ig Nobel Prize ceremony on Thursday 18 September, webcast at https://www.improbable.com/ig-about/the-30th-first-annual-ig-nobel-prize-ceremony/, for determining, experimentally,

what happens to the shape of a living earthworm when vibrated at high frequency.
- Excitation of Faraday-like body waves in vibrated living earthworms, Scientific Reports volume 10, 8564 (2020), https://doi.org/10.1038/s41598-020-65295-4

University of Adelaide

- Dr Lewis Mitchell and Professor Matthew Roughan together with Associate Professor James Bagrow (University of Vermont) have been awarded $390,000 for their discovery project *Mathematical modelling of information flow in social networks*.

University of Melbourne

- The university has been awarded an ARC Industrial Transformation Training Centre in Optimisation Technologies, Integrated Methodologies and Applications (OPTIMA), involving 19 Chief Investigators across University of Melbourne and Monash University, 11 industry partners, and 3 international partner organisations. OPTIMA will commence in 2021 and run for five years, with Kate Smith-Miles as Director.
- Dr Charl Ras, Emeritus Professor Doreen Thomas, and Associate Professor Marcus Brazil, together with Dr Michael Payne (Monash) and Professor Konrad Swanepoel (London School of Economics) have been awarded $385,000 for their discovery project *A unified approach to the design of minimum length networks*.
- Professor Christian Haesemeyer and Dr David Gepner, together with Dr Jack Hall (University of Arizona) and Professor Amnon Neeman (ANU), have been awarded $345,000 for their discovery project *Moduli, invariants, and algebraisation*.
- Professor Michael Cantoni, Dr Ye Pu (University of California) and Professor Chung-Yao Kao (National Sun Yat-Sen University) have been awarded $350,000 for their discovery project *Digitally networked dynamical systems: Performance and robustness analysis*.
- Dr Jesse Gell-Redman, Professor Paolo Piazza (University of Rome) and Associate Professor Pierre Albin (University of Illinois) have been awarded $395,000 for their discovery project *Singular spaces in analysis and geometry*.
- Dr Nora Ganter, Professor Paul Zinn-Justin, Dr Gufang Zhao and Dr Yaping Yang have been awarded $400,000 for their discovery project *Elliptic Schubert Calculus*.
- Professor Peter Forrester and Dr Mario Kieburg have been awarded $507,648 for their discovery project *Expanding and linking random matrix theory*.
- Associate Professor Iman Shames, Professor Jonathan Manton, Professor Chris Manzie, Dr Farhad Farokhi and Dr Airlie Chapman, together with Professor Anthony Man-Cho So (Chinese University of Hong Kong) and Dr Salem Said (University of Bordeaux), have been awarded $405,000 for

their discovery project *Design of real-time optimisation methods with guaranteed performance*.

- Professor James McCaw, Dr Nicholas Geard and Dr Rebecca Chisholm have been awarded $390,000 for their discovery project *Multiscale models in immuno-epidemiology*.
- Dr Daniel Murfet and Dr David Ridout, together with Dr Johanna Knapp (University of Vienna), have been awarded $395,311 for their discovery project *Proving the Landau-Ginzburg/Conformal Field Theory correspondence*.
- Dr Jesper Ipsen has been awarded $411,000 for the DECRA project *Stability and complexity: new insights from random matrix theory*.
- Dr Xi Geng has been awarded $330,000 for the DECRA project *Inverting the signature transform for rough paths and random processes*.
- Dr Stephane Dartois has been awarded $345,448 for the DECRA project *Random tensors and random matrices: interactions and applications*.
- Dr Alexandr Garbali has been awarded $42,346 for the DECRA project *Toroidal quantum groups, integrable models and applications*.

University of Newcastle

- Dr Stephan Tornier has been awarded $400,475 for the DECRA project *Effective classification of closed vertex-transitive groups acting on trees.*

University of South Australia

- Dr Bronwyn Hajek and Associate Professor Marta Krasowska, together with Professor Jonathan Wylie (City University of Hong Kong), have been awarded $225,000 for their discovery project *Pattern formation of precursor films: a new mathematical model*.

University of Sydney

- Simon Luo and Lamiae Azizi's proposal to the NSW Defence Network innovation has been selected for funding under the AI for Decision Making Initiative.
- Geordie Williamson is a 2020 Eureka Prize finalist.
- Professor Jean Yang is one of the Chief Investigators of a newly awarded NHMRC Centre of Research Excellence "Better Outcomes in Coronary Artery Disease".
- Professor Holger Dullin and Dr Robert Marangell, together with Professor Dr Yuri Latushkin (University of Missouri), have been awarded $310,000 for their discovery project *Spectral theory of Hamiltonian dynamical systems*.
- Associate Professor John Ormerod, Dr Garth Tarr and Professor Samuel Muller have been awarded $390,000 for their discovery project *Fast flexible feature selection for high dimensional challenging data*.
- Dr Kevin Coulembier and Dr Pavel Etingof (Massachusetts Institute of Technology) have been awarded $422,887 for the discovery project *New constructions and techniques for tensor categories*.

- Dr Alexander Fish has been awarded $340,000 for the discovery project *Additive combinatorics of infinite sets via ergodic theoretic approach.*
- Professor Nalini Joshi has been awarded $501,777 for the discovery project *Dynamics on space-filling shapes.*

University of Technology Sydney

- Professor Murray Elder, Dr Adam Piggott (Bucknell University) and Professor Dr Volker Diekert (University of Stuttgart) have been awarded $435,000 for their discovery project *Geodetic groups: foundational problems in algebra and computer science.*

University of Western Australia

- Shannon Algar has been awarded a Forrest Fellowship and appointed as research fellow on Dave Walker's ARC project.

UNSW Sydney

- Professor David Warton has been elected Fellow of the Royal Society of New South Wales.
- A/Professor Guoyin Li was featured as a field leader in Mathematical Optimisation in The Australian's Research 2020 magazine, for the second year in a row.
- Professor Mark Tanaka, together with Associate Professor Jeremy Kendal (Durham University), has been awarded $400,000 for the discovery project *How can cultural innovations trigger the emergence of new diseases?*
- Professor David Warton and Dr Jakub Stoklosa have been awarded $410,000 for their discovery project *Innovative statistical methods for analysing high-dimensional counts.*
- Professor Vaithilingam Jeyakumar and Associate Professor Guoyin Li, together with Dr Jean Lasserre (University of Toulouse), Professor Miguel Goberna (University of Alicante) and Professor Dr Immanuel Bomze (University of Vienna), have been awarded $400,000 for their discovery project *Data-driven multistage robust optimization: the new frontier in optimization.*
- Professor Frances Kuo and Emeritus Professor Ian Sloan have been awarded $630,000 for their discovery project *High dimensional computation and uncertainty.*
- Professor Gary Froyland has been awarded $440,000 for the discovery project *Modern mathematics to unravel the birth of coherence in dynamical systems.*
- Associate Professor Adelle Coster, Professor Dr Maria Vlasiou (Technical University of Eindhoven) and Assistant Professor Marko Boon (Technical University of Eindhoven) have been awarded $435,000 for their discovery project *The mathematics of stochastic transport and signalling in cells.*

Appointments, departures and promotions

Australian National University

- Christopher Raymond commenced as a Postdoctoral Fellow.
- Jonathan Zhu commenced as a Research Fellow.
- Jim Borger has been promoted to Associate Professor.
- Anand Deopurkar has been promoted to Senior Lecturer.

Curtin University

- Professor Victor Calo will be joining the Maths/Stats discipline from the start of 2021. Victor is currently a John Curtin Distinguished Professor in the School of Earth and Planetary Sciences and he has been working at Curtin since 2016.

Federation University

- Professor Alex Kruger has accepted a voluntary redundancy and will officially retire in December.

La Trobe University

- After many years at LTU, Kevin Bicknell retired in July 2020.
- Dr Mumtaz Hussain has been appointed as the Associate Editor of the Bulletin of the Australian Mathematical Society.

Macquarie University

Staff farewelled:

- Professor Jim Denier, a former Head of The Department of Mathematics and Statistics, officially retired this year.
- Dr Christopher Green has moved to Wichita State University.
- Dr David Arnold was granted voluntary redundancy with last working day of 27 November 2020.
- Dr Kenneth Beath was also granted voluntary redundancy and will retire in November 2020. He will remain affiliated with the Department.
- Professor Vladimir Gaitsgory accepted voluntary redundancy and will officially retire in November. He will remain affiliated with the Department.

RMIT University

- Dr Sevvandi Kandanaarachchi started at RMIT University as a lecturer in February 2020. She completed her PhD at Monash University in 2011, after which she was employed at DigiPen Institute of Technology, Singapore in a fully teaching capacity. Before joining RMIT she also had postdoctoral appointments at the University of Melbourne and Monash University. She is interested in data science related topics such as anomaly and event detection and real-world applications.

UNSW Sydney

- Pinhas Grossman and Jan Zika have been promoted to the level of Associate Professor, which will take effect from 1 January 2021.
- The Head of School of Mathematics and Statistics at UNSW Sydney, Professor Bruce Henry, will retire on 18 December 2020. Bruce will continue to maintain links and research as an Emeritus Professor in the School.
- Dr Chi Mak and Dr Milan Pahor have accepted voluntary redundancies.

New Books

La Trobe University, University of Adelaide and University of Melbourne

Owen Dearricott and Yuri Nikolayevsky (La Trobe), Thomas Leistner (Adelaide) and Diarmuid Crowley (Melbourne) are amongst the five editors of the recently published book:

Dearricott, O., Tuschmann, W., Nikolayevsky, Y., Leistner, T. and Crowley, D. (eds) (2020). *Differential Geometry in the Large* (London Mathematical Society, Lecture Note Series 463). Cambridge University Press.

DOI: https://doi.org/10.1017/9781108884136.

https://www.cambridge.org/core/books/differential-geometry-in-the-large/388C1A33D0348AD8D556F3D72F051DAB

University of Wollongong

Jennifer Seberry (Wollongong) and Mieko Yamada (Kanazawa University, Japan) are the authors of the recently published book:

Seberry, J. and Yamada, M. (2020). *Hadamard Matrices: Constructions using Number Theory and Linear Algebra*. Wiley. ISBN:9781119520245, 111952024X

Conferences and Courses

Conferences and courses are listed in order of the first day.

Information given here is the most up to date supplied to us at the time of going to press. In view of the disruption caused by CoViD-19, you should check the links given, or directly with the organisers, for updates.

2020 AustMS Early-Career Workshop (ECW)

Date: Monday December 7
Venue: will be held online
Web: http://web.science.mq.edu.au/~sophiec/

The ECW is intended for current higher-degree research students and ECRs (up to roughly five years post-PhD) and will precede the 64th Annual Meeting of the Australian Mathematical Society.

Registration is free! Speaker info, a provisional schedule, and the registration form can be found on the website.

64th Annual Meeting of the Australian Mathematical Society

Dates: Tuesday 8 December 2020 to Friday 11 December 2020
Venue: Virtual event hosted by the University of New England
Web: https://austms.org.au/meetings/annual-conferences/2020-austms-meeting/#home

Full details are available on the website. Please note that the Satellite Conference *Mathematics of String Theory AU* has been POSTPONED, new dates to be announced.

CMSA Day

Date: Tuesday 15 December 2020
Venue: Zoom
Web: http://combinatorics-australasia.org/CMSA-Day.html

The Council of the Combinatorial Mathematics Society of Australasia (CMSA) will hold this one-day workshop as a partial replacement for the postponed conference 43ACC. The workshop will be held on Zoom, with talks from:

- Noga Alon (Princeton University and Tel Aviv University)
- Nick Cavenagh (University of Waikato)
- Alice Devillers (University of Western Australia)
- Lisa Sauermann, (Institute for Advanced Study)

We also invite participants to attend the CMSA Annual General meeting which takes place at 1pm AEDT.

This is a free event but provides a great opportunity to renew your CMSA membership or become a new member of the CMSA! When registering, you will have

the option of a free ticket (without CMSA membership) or a paid ticket of approximately $26 which comes with CMSA membership for 2021. If you are already a CMSA *life member* then you should select the free ticket option. If you have access to research funding then we encourage you to purchase a paid ticket. Registration is available at the website.

Organisers: Catherine Greenhill, Sara Herke, Nina Kamcev, Anita Liebenau, Jeanette McLeod and Ian Wanless.

AMSI Summer School 2021

Dates: 11 January to 5 February 2021 (note change)
Venue: Virtual event hosted by the University of Adelaide
Web: https://ss.amsi.org.au/

The AMSI Summer School 2021 program offers eight carefully selected subjects to ensure the latest developments in Australian maths are offered to students, some of which may not be offered at a home university. Students can choose to study one or two courses and, with permission from a home university, students can use an AMSI Summer School subject to gain credit towards their degree.

The School is primarily for honours and postgraduate students in the mathematical sciences and cognate disciplines, but other students are welcome to apply.

Practical Applications of Network Science

Dates: 22 and 23 February 2021
Venue: online, hosted by RMIT University
Web: https://sites.google.com/view/nsworkshop2021/home

This workshop has the aim of developing the skills of HDR students and bringing together researchers in the field. Invited research talks will cover a broad range of topics including the use of network science in transportation, biology and social media. This workshop will consist of:

(a) Two hands-on tutorial/lab sessions in the mornings on network analytics using the R software environment. The sessions will start from an introductory level on the first day and proceed to working with real-world applications on the second day.

(b) Invited research talks showcasing network science and its applications in the afternoons followed by time for networking opportunities.

This is a free event, but registration is essential. More details at the website.

Computational & Algorithmic Topology, Sydney (CATS 2020)

Dates: 26–30 July 2021
Venue: The University of Sydney
Web: https://sites.google.com/view/cats-2020

The meeting has been postponed from 2020. The dates have changed but everything else stays the same.

Structured Random Matrices in Down Under: New Developments and Applications

Dates: 26 July to 13 August 2021
Venue: MATRIX centre, Creswick
Web: https://www.matrix-inst.org.au/events/structured-random-matrices-in-down-under-new-developments-and-applications/

The program shall bring together scientists from very different fields to discuss similar problems that deals with structured random matrices. For this purpose, it is advantageous to bring the whole spectrum from mathematicians to physicists and engineers in contact. The contrast between models and real life problems should show in which direction the models have to be further developed.

During the three-week program, the first and third weeks will focus on collaborations and research. The second week will take the form of a workshop presenting the state of the art of the field of structured matrices in its full breath and giving the researchers the opportunity to demonstrate their results.

Registration Deadline: 26 May 2021. Registration is by invitation only. If you are interested to participate in this research program, please contact one of the organisers with your CV and research background.

Cartan Subalgebras in Operator Algebras

Dates: 16–27 August 2021
Venue: MATRIX centre, Creswick
Web: https://www.matrix-inst.org.au/events/cartan-subalgebras-in-operator-algebras/

The central focus of this program is the role of Cartan subalgebras in two branches of operator algebras: C^*-algebras and von Neumann algebras. The program will involve researchers from four Australian institutions (UNSW, USyd, UNE, and UOW), and international experts who are at the forefront of the study of Cartan subalgebras. The focus on research and collaboration time during the program will give all participants the best chance to establish concrete projects which can be continued and completed after the workshop.

The first week of our program will feature two mini-courses, aimed at PhD students, which will introduce junior researchers and non-experts to the ideas and techniques needed to participate in this exchange of ideas between the two branches. In the second week, experts on Cartan subalgebras will give lectures on recent developments, connections and applications, with a focus on educating researchers from the other branch.

WIMSIG (Women in Mathematics Special Interest Group) 2020

Dates: 29 September to 1 October 2021
Venue: Monash University
Web: https://www.austms.org.au/WIMSIG-conference-2020

The WIMSIG Conference has been postponed by exactly one year; please update your calendars.

The Mathematics of Conformal Field Theory II (POSTPONED)

Dates: sometime in 2021 (postponed from July 2020)
Venue: Australian National University
Web: https://maths.anu.edu.au/news-events/events/mathematics-conformal-field-theory-ii

This event has been postponed due to COVID-19. It will take place in 2021: dates to be confirmed.

Aboriginal and Torres Strait Islander Mathematics Alliance 2020 Conference (POSTPONED)

Dates: sometime in 2021 (postponed from July 2020)
Venue: Yirrkala, Northeast Arnhem Land
Web: https://atsimanational.ning.com/conference-2020-postponement
Contact: Melinda Pearson, 0414 322 372 or melindapearson@atsima.org

Elliptic Partial Differential Equations, Geometry, and the Calculus of Variations

Dates: 1–12 November 2021
Venue: MATRIX centre, Creswick
Web: https://www.matrix-inst.org.au/events/elliptic-partial-differential-equations-geometry-and-the-calculus-of-variations/

Isoperimetric Inequalities in Geometric Partial Differential Equations

Dates: 15–26 November 2021
Venue: MATRIX centre, Creswick
Web: https://www.matrix-inst.org.au/events/isoperimetric-inequalities-in-geometric-partial-differential-equations/

Groups and Geometries

Dates: 29 November to 3 December 2021
Venue: MATRIX centre, Creswick
Web: https://www.matrix-inst.org.au/events/groups-and-geometries/

Mathematica Solis et Terrae

Dates: 2–3 December 2021 (rescheduled)
Venue: Australian National University, Canberra
Web: https://maths.anu.edu.au/news-events/events/math%C4%93matica-s%C5%8Dlis-et-terrae-australian-academy-science-elizabeth-and-frederick

This event was originally scheduled in the MSI Special Year 2020 – Mathematical Physics calendar but has been rescheduled to 2021 due to COVID-19.

The rapid progress and expansion of computational power will soon reach the exascale, and provide the computing power to solve a new class of problems. The enabling science of high-performance computing is computational mathematics: permitting solution to high dimensional problems, improving the efficiency of calculation, and robustly quantifying uncertainty.

Mathematica Solis et Terrae is a two-day research conference. It will bring together a diverse group of disciplines to share challenges and explore synergies in high performance computing simulation in the fields of the solid Earth (geophysics), land-atmosphere carbon exchange (earth systems science), and solar physics.

The conference will cover topics in numerical analysis (e.g. Galerkin methods, spline-based techniques, sparse-grids, uncertainty quantification and matching layers) and applications in geophysics, Earth system science and solar and astrophysics.

Abstract submissions for contributed talks and student posters will open soon.

Quantum Curves, Integrability and Cluster Algebras

Dates: 6–17 December 2021
Venue: MATRIX centre, Creswick
Web: https://www.matrix-inst.org.au/events/quantum-curves-integrability-and-cluster-algebras/

The 43rd Australasian Combinatorics Conference (43ACC)

Dates: probably early- or mid-December 2021
Venue: The University of Melbourne
Web: http://43acc.ms.unimelb.edu.au

POSTPONED from 14–18 December 2020

After a careful assessment of the potential impact of the COVID-19 pandemic to this conference and following a suggestion of the CMSA Council, we have decided to postpone 43ACC to December 2021. At this stage we are unable to confirm exact dates, but it is likely that 43ACC will be postponed until early or middle December 2021. (The AustMS annual meeting usually takes place in December, and we will try to avoid clash with 2021 AustMS meeting.) Once finalised, the exact dates will be published on the website.

Statistics in Ecological Modelling: current gap and approaches

Dates: 10–14 January 2022
Venue: MATRIX, Creswick
Web: under development

This MATRIX workshop will be organised by

- Yan Wang (RMIT University),
- Nokuthaba Sibanda (Victoria University of Wellington),
- Gordana Popovic (University of New South Wales),
- Ian Flint (University of Melbourne).

International Congress of Mathematicians

Dates: 6–14 July 2022
Venue: Saint Petersburg, Russia
Web: https://icm2022.org

Visiting mathematicians

International visitors who arrived before the border closures are listed here. Their details are presented in the format: name of visitor; home institution; dates of visit; principal field of interest; principal host institution; contact for enquiries.

Teresa Dias; Federal University of Sao Carlos; March 2020 to February 2021; UWA; Adriano Polpo

A/Prof Kreangkri Ratchagit; Maejo University, Chiang Mai, Thailand; 1 March 2020 to 31 January 2021; difference equations and systems theory; CUT

Dr Gen Sakurai; Institute for Agro-Environmental Sciences, National Agricultural and Food Research Organization, Japan; December 2019 to March 2021; mathematical modelling of plant physiology; USA; Stanley J. Miklavcic

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Reminder of the 64th Annual Meeting of the AustMS

Dates: Tuesday 8 December to Thursday 10 December 2020
Venue: Online

Please register before November 16th. The conference is free for members of the AustMS (note that registration is still required in this case) and $50 for non-members. For a non-member, the $50 fee may be used towards an AustMS membership. Registration is also free for members of international mathematical partner societies.

Register at:
https://austms.org.au/meetings/annual-conferences/2020-austms-meeting/

For enquiries please contact Gerd Schmalz (schmalz@une.edu.au).

Reminder of the Society's Annual General Meeting

The Society's 64th Annual General Meeting will be held on Thursday 10 December at 5 pm via zoom, during the Society's annual conference. The agenda and papers for the meeting will be posted on the conference website about a week before the meeting.

AustMS Accreditation

The following members have been accredited a Fellow (FAustMS):

- Associate Professor Katherine Seaton of La Trobe University
- Mr Joseph Forbes, co-founder Biarri

The following member has been accredited a Member (MAustMS):

- Dr Christopher Kelly, Kelly & Yang

Deborah Jackson AustMS Secretary
Email: Secretary@AustMS.org.au

Deborah Jackson (née Trueman) is a lecturer at La Trobe University. She began her academic career at Monash University and then moved to Swinburne University. After several years back at Monash, she joined La Trobe in 2010. Deborah was honorary Chair of the Victorian Algebra Group from 1996 to 2003 and its Secretary from 1994 to 1995. Deborah took over as Secretary of the Society in September 2019.

The Australian Mathematical Society

President:	Prof Jacqui Ramagge, FAustMS MAICD	School of Mathematics and Statistics The University of Sydney NSW 2006, Australia. jacqui.ramagge@sydney.edu.au
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Membership and Correspondence

Applications for membership, notices of change of address or title or position, members' subscriptions, correspondence related to accounts, correspondence about the distribution of the Society's publications, and orders for back numbers, should be sent to the Treasurer. All other correspondence should be sent to the Secretary. Membership rates and other details can be found at the Society web site: www.austms.org.au.

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Publications

The Journal of the Australian Mathematical Society

Editor: Professor Jon Berrick
Sydney Mathematical Research Institute (SMRI)
The University of Sydney, NSW 2006, Australia

The ANZIAM Journal

Editor: Professor Andrew Bassom
School of Mathematics and Physics
University of Tasmania, Australia

Editor: Professor Graeme Hocking
School of Chemical and Mathematical Sciences
Murdoch University, WA 6150, Australia

Bulletin of the Australian Mathematical Society

Editor: Professor John Loxton
Western Sydney University, Penrith, NSW 2751, Australia

The *Bulletin of the Australian Mathematical Society* aims at quick publication of original research in all branches of mathematics. Two volumes of three numbers are published annually.

The Australian Mathematical Society Lecture Series

Editor: Professor Jacqui Ramagge
School of Mathematics and Statistics
The University of Sydney, NSW 2006, Australia

The lecture series is a series of books, published by Cambridge University Press, containing both research monographs and textbooks suitable for graduate and undergraduate students.

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