



Australian Mathematical Society  
Australian and New Zealand Industrial and Applied Mathematics



The 62nd ANZIAM Conference  
8–12 February 2026  
Canberra, Australia

The talk abstracts in this volume were typeset by their authors. Only minor typographical changes have been made by the editors. The opinions, findings, conclusions and recommendations in this book are those of the individual authors.

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## 1 Acknowledgement of Country

We wish to acknowledge the Ngunnawal people as traditional custodians of the land we are meeting on and recognise any other people or families with connection to the lands of the ACT and region. We wish to acknowledge and respect their continuing culture and the contribution they make to the life of this city and this region.

## 2 Conference Code of Conduct

ANZIAM is committed to a professional, open, productive and respectful exchange of ideas. These aims require a community and environment that fosters inclusion, provides mutual respect and embraces diversity. A condition of registering to attend the ANZIAM 2026 Conference and/or any associated satellite event is agreeing to the following Code of Conduct:

Harassment in any form will not be tolerated. This includes, but is not limited to, speech or behaviour (whether in person, in presentations or in online discussions) that intimidates, creates discomfort, prevents or interferes with a person's participation or opportunity for participation in ANZIAM's vision and mission. We aim for ANZIAM to be an organisation where harassment in any form does not happen, including but not limited to: harassment based on race, gender, religion, age, colour, national or ethnic origin, ancestry, disability, marital status, sexual orientation or gender identity. Harassment includes but is not limited to: verbal comments that reinforce social structures of domination; sexual images in public spaces; deliberate intimidation, stalking or following; harassing photography or recording; sustained disruption of talks or other events; inappropriate physical contact; unwelcome sexual attention; and advocating for or encouraging any of the above behaviour.

Conference organisers will take seriously all reports of breaches of this Code of Conduct, and treat all parties with respect and due process without presupposition of guilt. Complaints will be handled with sensitivity, discretion and confidentiality. If a conference participant engages in harassing behaviour, they may be asked by the conference organisers to leave the conference. Any event participant who experiences or witnesses harassment should contact one of the following Code of Conduct representatives:

- Jennifer Flegg
- Bronwyn Hajek
- Mark McGuinness
- Claire Miller
- Matthew Simpson
- Natalie Thamwattana

## 3 Conference Details and History

### 3.1 Organising committee

- Simon Watt, UNSW Canberra (Chair)
- Zlatko Jovanoski, UNSW Canberra
- Tim McLennan-Smith, DSTG
- Jason Sharples, UNSW Canberra
- Leesa Sidhu, UNSW Canberra
- Linda Stals, ANU
- Isaac Towers, UNSW Canberra
- Kate Turner, ANU

### 3.2 Invited speaker committee

- Jennifer Flegg, University of Melbourne (Chair)
- Simon Watt, UNSW Canberra (Conference rep)
- Cecilia González-Tokman, University of Queensland
- Ilze Ziedins, University of Auckland
- Yvonne Stokes, University of Adelaide
- Jason Sharples, UNSW Canberra
- Serena Dipierro, University of Western Australia
- Roslyn Hickson, James Cook University/CSIRO
- Ricardo Ruizbaier, Monash University
- Chris Angstmann, University of New South Wales
- Matthew Tam, University of Melbourne
- Lauren Smith, University of Auckland
- Andrew Bassom, University of Tasmania

### 3.3 Plenary speakers

- A/Prof Matthew Tam, University of Melbourne
- Prof Jennifer Flegg, University of Melbourne
- Prof Andrew Bassom, University of Tasmania
- Prof Natalie Thamwattana, University of Newcastle
- Prof Boris Baeumer, University of Otago
- Prof Mary Silber, University of Chicago
- Dr Edgar Duéñez-Guzmán, Gilbran AI
- Prof Kavita Ramanan, Brown University

### 3.4 Past conference locations

1966	Kangaroo Island (Aug)	1986	Wirrina	2007	Fremantle
1966	Coorong (Dec)	1987	Wairakei	2008	Katoomba
1967	Adelaide	1988	Leura	2009	Caloundra
1968	Halls Gap	1989	Ballarat	2010	Queenstown
1969	Victor Harbor	1990	Coolangatta	2011	Glenelg
1970	Lorne	1991	Hanmer Springs	2012	Warrnambool
1971	Smiggin Holes	1992	Batemans Bay	2013	Newcastle
1972	Wollongong	1993	Hahndorf	2014	Rotorua
1973	Surfers Paradise	1994	Pokolbin	2015	Surfers Paradise
1974	Lorne	1995	Busselton	2016	Canberra
1975	Tanunda	1996	Masterton	2017	Hahndorf
1976	Jindabyne	1997	Lorne	2018	Hobart
1977	Terrigal	1998	Coolangatta	2019	Nelson
1978	Broadbeach	1999	Mollymook	2020	Hunter Valley
1979	Leura	2000	Waitangi	2021	Cape Schanck <sup>1</sup>
1980	Cowes	2001	Barossa Valley	2022	Perth <sup>1</sup>
1981	Victor Harbor	2002	Canberra	2023	Cairns
1982	Bundanoon	2003	Sydney	2024	Hahndorf
1983	Perth	2004	Hobart	2025	Coffs Harbour
1984	Merimbula	2005	Napier	2026	Canberra
1985	Launceston	2006	Mansfield		

<sup>1</sup> online due to COVID-19

### 3.5 ANZIAM Medal

The ANZIAM Medal is awarded on the basis of research achievements or activities enhancing applied or industrial mathematics and contributions to ANZIAM. The first award was made in 1995. Past recipients are listed below.

1995	Renfrey Potts	U. Adelaide	2016	Frank de Hoog	CSIRO Canberra
1997	Ian Sloan	UNSW	2018	Phil Howlett	UniSA
1999	Ernie Tuck	U. Adelaide	2019	Peter Taylor	U. Melbourne
2001	Charles Pearce	U. Adelaide	2020	Larry Forbes	U. Tasmania
2004	Roger Grimshaw	Loughborough U.	2021	Nalini Joshi	U. Sydney
2006	Graeme Wake	Massey U.	2022	Phil Broadbridge	LaTrobe
2008	James Hill	UoW	2023	Tony Roberts	U. Adelaide
2010	Bob Anderssen	CSIRO	2024	Hinke Osinga	U. Auckland
2012	Robert McKibbin	Massey U.	2025	Andrew Bassom	U. Tasmania
2014	Kerry Landman	U. Melbourne			

### 3.6 The E.O. Tuck Medal

In honour of the late Ernest Oliver Tuck, FAustMS, FTSE and FAA, ANZIAM has instituted a mid-career award for outstanding research and distinguished service to the field of Applied Mathematics. The inaugural E. O. Tuck Medals were presented at ANZIAM 2013. Past recipients are listed below.

2013	Geoffrey Mercer	ANU	2020	Matthew Simpson	QUT
	Shaun Hendy	VUW and Callaghan Innov.	2021	Michael Plank	U. Canterbury
2015	Troy Farrell	QUT	2022	James McCaw	U. Melbourne
2017	Kate Smith-Miles	Monash U.	2023	Luke Bennetts	U. Adelaide
2018	Yvonne Stokes	U. Adelaide	2024	Alex James	U. Canterbury
2019	Scott McCue	QUT	2025	Jennifer Flegg	U. Melbourne

### 3.7 The J.H. Michell Medal

The J. H. Michell Medal is awarded to outstanding new researchers who have carried out distinguished research in applied or industrial mathematics, where a significant proportion of the research work has been carried out in Australia or New Zealand. Past recipients are listed below.

1999	Harvinder Sidhu	UNSW	2014	Ngamta Thamwattana	UoW
2000	Antoinette Tordesillas	U. Melbourne	2015	Barry Cox	U. Adelaide
2001	Nigel Bean	U. Adelaide	2016	Joshua Ross	U. Adelaide
2002	Stephen Lucas	UniSA	2017	Alys Clark	U. Auckland
2004	Mark Nelson	UoW	2018	Claire Postlethwaite	U. Auckland
2006	Sanjeeva Balasuriya	U. Sydney	2019	Ryan Loxton	Curtin U.
2007	Yvonne Stokes	U. Adelaide	2020	Jennifer Flegg	U. Melbourne
2008	Carlo Laing	Massey U.	2021	Lewis Mitchell	U. Adelaide
2009	Scott McCue	QUT	2022	Elliot Carr	QUT
2011	Frances Kuo	UNSW	2023	Christopher Lustri	Macquarie U.
2012	Matthew Simpson	QUT	2024	Vivien Challis	QUT
2013	Terence O'Kane	CMAR CSIRO	2025	Matthew Tam	U. Melbourne

### 3.8 The K.A. Landman Medal

In honour of Emeritus Professor Kerry Anne Landman FAA, ANZIAM has instituted an award to recognise outstanding contributions of our members to the field of industrial mathematics. ANZIAM recognises industrial mathematics as a diverse discipline, with the fundamental definition being the use of mathematical and computational techniques to solve complex problems for industry (including government and non-profit sectors). At most one award will be made annually, but only to a candidate of sufficient merit. No person can receive more than one such award. The inaugural award will be presented at ANZIAM 2026 by Kerry Landman.

### 3.9 The ANZIAM Outstanding PhD Theses Award

This award, which recognises outstanding doctoral work in applied mathematics published at an Australian or New Zealand University, will comprise of a certificate and a waiver of the registration fee for the following ANZIAM conference.

### 3.10 The T.M. Cherry Student Prize

A student prize was introduced in 1969 at Victor Harbor and is awarded annually for the best student talk presented at the conference. In May 1976, ANZIAM (then the Division of Applied Mathematics) adopted the title “T.M. Cherry Student Prize” in honour of one of Australia’s leading scientists, Professor Sir Thomas MacFarland Cherry. Past recipients are listed below.

1969	R. Jones	U. Adelaide	1992	S. F. Brown	UoW
1970	J. Rickard	UCL	1993	D. Standingford	U. Adelaide
1971	J. Jones	Mount Stromlo	1994	B. Barnes	Monash U.
1974	R. P. Oertel	U. Adelaide	1995	A. Buryak	ANU
1975	R. E. Robinson	U. Sydney	1996	A. Gore	U. Newcastle
1976	J. P. Abbott	ANU		D. Scullen	U. Adelaide
1977	J. Finnigan	CSIRO	1997	S. Cummins	Monash U.
	S. Bhaskaran	U. Adelaide	1998	J. Clark	U. Sydney
1978	B. Hughes	ANU		T. Gourlay	U. Adelaide
	P. Robinson	UQ	1999	E. Ostrovskaya	ANU
1979	J. R. Coleby	U. Adelaide	2000	C. Reid	Massey U.
	B. Hughes	ANU	2001	M. Haese	U. Adelaide
1980	M. Lukas	ANU	2002	V. Gubernov	ADFA
1981	A. Plank	UNSW		W. Megill	UBC/UoW
1982	G. Fulford	UoW	2003	Not awarded	
	J. Gear	U. Melbourne	2004	K. Mustapha	UNSW
1983	P. Kovesi	UWA	2005	J. Looker	U. Melbourne
1984	A. Kucera	UoW	2006	C. Fricke	U. Melbourne
	S. Wright	UQ	2007	S. Harper	Massey U.
1985	G. Fulford	UoW	2008	E. Button	U. Melbourne
	F. Murrell	U. Melbourne		M. Haythorpe	UniSA
1986	A. Becker	Monash U.	2009	S. Cohen	U. Adelaide
	K. Thalassoudis	U. Adelaide	2010	L. Mitchell	U. Sydney
1988	W. Henry	ANU	2011	S. Butler	U. Sydney
1987	M. Rumsewicz	U. Adelaide		J. Caffrey	U. Melbourne
1989	M. Myerscough	U. Oxford	2012	J. Nassios	U. Melbourne
	J. Roberts	U. Melbourne	2013	D. Khoury	UNSW
1990	J. Best	UoW		T. Vo	U. Sydney
1991	S. K. Lucas	U. Sydney	2014	M. Chan	U. Sydney

2015	Hayden Tronolone	U. Adelaide	2021	Alex Browning	QUT
2016	David Arnold	U. Adelaide		Rahil Valani	Monash U.
	Adrienne Jenner	U. Sydney	2022	Adriana Zanca	U. Melbourne
2017	Claire Miller	U Melbourne		Michael Denes	UNSW
	Eric Hester	U. Sydney	2023	Sarah Vollert	QUT
2018	Nabil Fadai	U. Oxford		Kyria Wawryk	Monash U.
	Eloise Tredenick	QUT	2024	Patrick Grant	QUT
2019	Elle Musoke	U. Auckland	2025	Juan Patiño-Echeverri	U. Auckland
	Conway Li	UWA		Kaitlyn Brown	QUT
2020	Rose Crocker	U. Adelaide			

### 3.11 The Cherry Ripe Prize

Since 1995 the students have run an alternative competition for the best non-student talk. Past recipients are listed below.

1995	Natashia Boland	U. Melbourne	2012	Martin Wechselberger	U. Sydney
1996	Andrew Pullan	U. Auckland	2013	Scott McCue	QUT
1997	Neville de Mestre	Bond U.		Sheehan Olver	U. Sydney
1998	David Stump	UQ	2014	Peter Kim	U. Sydney
1999	Mark McGuinness	VUW	2015	Not awarded	
2000	Joseph Monaghan	Monash U.	2016	Matthew Simpson	QUT
	Andy Philpott	U. Auckland		Melanie Roberts	IBM Research Australia
2001	Phil Broadbridge	UoW	2017	Christopher Green	QUT
2002	Ernie Tuck	U. Adelaide	2018	Christopher Lustrì	Macquarie U.
	Larry Forbes	U. Tasmania	2019	Raúl Rojas	Freie Universität Berlin
2004	Stephen Lucas	UniSA	2020	Mike Meylan	U. Newcastle
2005	Kerry Landman	U. Melbourne		Peter Taylor	U. Melbourne
2006	Vicky Mak	Deakin U.	2021	J. Nathan Kutz	Washington
	James Sneyd	U. Auckland	2022	Jennifer Flegg	U. Melbourne
2007	Geoffrey Mercer	USW		Adrienne Jenner	QUT
2008	Neville de Mestre	Bond U.	2023	Adrienne Jenner	QUT
2009	Philip Maini	U. Oxford	2024	Larry Forbes	U. Tasmania
2010	Larry Forbes	U. Tasmania	2025	Maria Kleshnina	QUT
2011	Larry Forbes	U. Tasmania			
	Darren Crowdy	Imperial College			

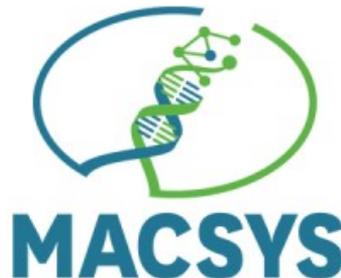
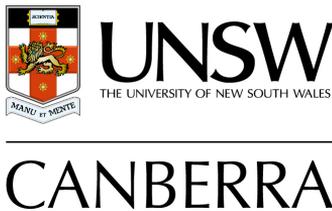
### 3.12 The A.F. Pillow Applied Mathematics Top-up Scholarship

The A. F. Pillow Applied Mathematics Trust offers an annual “top-up” scholarship to a student holding either an Australian Postgraduate Award (APA) or equivalent award for full-time research in Applied Mathematics leading to the award of a PhD. The aim of the A. F. Pillow Applied Mathematics Top-up Scholarship is to increase the quality of postgraduate students in the field of Applied Mathematics in Australia. Past recipients are listed below.

2009	Christopher Lustri	QUT	2017	Jody Fisher	Flinders U.
2010	Alex Badran	UoW	2019	Jesse Sharp	QUT
2011	Michael Dallaston	QUT	2020	Matthew Berry	UoW
2012	Hayden Tronnolone	U. Adelaide	2022	Eugene Tan	UWA
2013	Lisa Mayo	QUT	2023	Noa Levi	QUT
2014	Audrey Markowskei	Macquarie U.	2024	Yong See Foo	U. Melbourne
2015	Pouya Baniyadi	Flinders U.	2025	Liam Blake	U. Adelaide
2016	Alexander Tam	U. Adelaide			

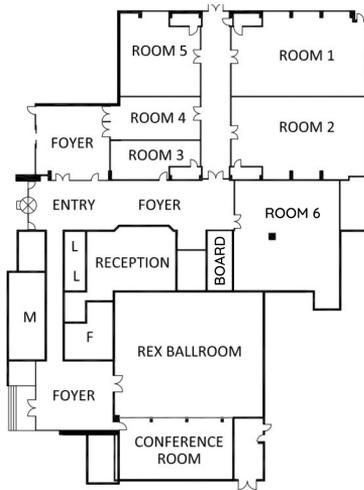
### 3.13 Acknowledgements

The Organising Committee would like to express our heartfelt gratitude to John Banks from The University of Melbourne for his invaluable assistance in developing and maintaining the online conference registration system. We also extend our thanks to Michael Lydeamore from Monash University for his support in managing the financial aspects of the conference. Finally, the committee sincerely appreciates the backing of the following organisations.

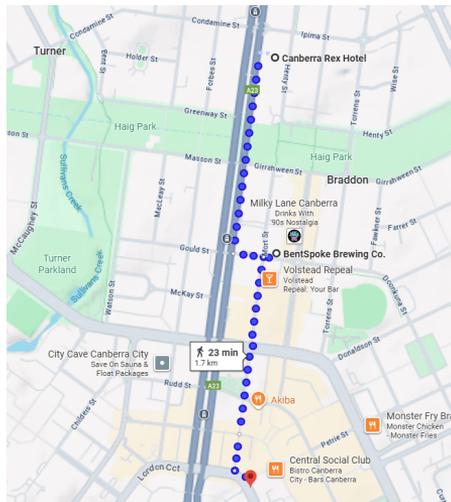


## 4 Conference Venue

The conference is being held at the Canberra Rex Hotel in Canberra. The Canberra Rex is located at 150 Northbourne Avenue, Braddon ACT 2612, about two kilometres to the north of the Canberra CBD. The floor plan is shown below.



For those wishing to walk to the CBD, see the map below.



Note that there is a light rail stop outside the Rex, but you need to purchase a **MyWay+** card.

## 4.1 Conference Reception

The welcome reception will be held in the Rex Ballroom on Sunday 8 February from 6.30pm. All conference delegates are invited.

## 4.2 Conference Dinner

The conference dinner will be held at the Canberra Rex in the Grand Ballroom on Wednesday 11 February beginning with pre-dinner drinks from 6.30pm. Please make sure you have registered and paid for the dinner beforehand. Also, make sure you have entered any dietary requirements.

## 4.3 Refreshment Breaks and Lunches

Morning and afternoon tea and light refreshments will be available in the Rex Ballroom. Lunches are included in the registration fee and will be available in the Rex Ballroom after the last presentations of the morning sessions on Monday, Wednesday and Thursday. On Tuesday, lunches will be available in Room 6.

## 4.4 Internet Access

WiFi access is available using the **Rex Conference** access point using the code `rexconf2018`

## 4.5 Social Media

ANZIAM attendees are encouraged to use social media from their personal accounts to share ideas from the conference. The conference hashtag is #ANZIAM2026. It is good practice to include a reference to the presenter and their affiliation, and please seek permission from the presenter before posting a video of them or their presentation online.

## 4.6 Student Event

All students are invited to the student event on Monday 12 February at 6.30pm. It will be held at Grease Monkey (19 Lonsdale St, Braddon). The event provides a chance to meet fellow students in an informal setting, with food and non-alcoholic drinks provided.

## 4.7 LGBTQIA+ and Allies lunch

We invite everyone in applied mathematics to join us for a lunchtime gathering celebrating our LGBTQIA+ community and allies. This event provides an inclusive space to strengthen connections and reflect on the value of diversity in mathematics. All are welcome to attend, regardless of identity, to share in open conversation and community building. The lunch will be held on Level 5. Tickets are free but you must have registered through the conference registration system before 31 January.

## 4.8 Women in Mathematics Special Interest Group Lunch

The WIMSIG lunch is held at national ANZIAM conferences to promote and celebrate the contribution of women, trans and gender diverse people in the mathematical sciences. Conference delegates of any gender are encouraged to attend and participate in the discussion. Tickets are free but you must have registered through the conference registration system before 31 January. The lunch will be held in parallel to the main conference lunch on Tuesday 10 February and will be held in the Rex Ballroom.

Lunch is supported by James McCaw.

## 4.9 ANZIAM AGM

The 51<sup>st</sup> AGM of ANZIAM will be held at 7.30pm (AEST) on Tuesday 10 February in the plenary room (Rooms 1 and 2) and on Zoom. All ANZIAM members are welcome and encouraged to attend this meeting. The link for the agenda and reports will be emailed to all members a week prior to the AGM.

## 4.10 Early Career Workshop

The Early Career Workshop will be held at the Mathematical Sciences Institute at ANU the weekend before the ANZIAM conference. The workshop will run from 1:30pm–4:30pm Saturday, with a dinner (free to workshop attendees) Saturday night, and 9:30am–12:30pm Sunday, followed by a catered lunch.

The workshop will target both postdoctoral students and postdoctoral/research fellows. Session topics will include networking, communication, and careers, facilitated by a great lineup of academics.

A big thanks to AustMS for providing the financial support to run this workshop.

The following is the preliminary schedule for the workshop. Note, this is still subject to change.

Location: ANU Campus (room information to come)

### Saturday 7 February

Time: 1:30–4:30 pm

Catering: Afternoon tea

Session Topics:

- Presentation Skills
- Postdoctoral Expectations
- Networking

Dinner: 6:30 pm (Assembly, 11 Lonsdale Street, Braddon).

### Sunday 8 February

Time: 9:30 am–12:30 pm

Catering: Morning tea and lunch

Session Topics:

- Grant and Project Development
- Engaging with Government and Industry

Workshop End: 12:30 pm (followed by lunch).

## 4.11 Optimisation Workshop

SigmaOpt, the optimisation special interest group of ANZIAM, is holding a one-day workshop at the Australian National University on the day after the 2026 ANZIAM Conference. The workshop will feature talks from our invited speakers, as well as the Winner of the Student Best Paper Prize. Important Information:

- When: Friday February 13, 2026
- Where: Australian National University, Canberra
- Invited Speakers:
  - Hoa Bui (Curtin)
  - Philipp Braun (ANU)
  - Bethany Caldwell (UNSW)
  - Mahdi Abolghasemi (QUT)
  - James Nichols (Macquarie Bank/ANU)
  - The Winner of the Student Best Paper Prize (TBA)
- Registration: \$50 (includes catering).

For further information about the workshop, download the poster at [https://www.anziam.org.au/tiki-download\\_file.php?fileId=199](https://www.anziam.org.au/tiki-download_file.php?fileId=199) (PDF, 244 KB).

## 4.12 Mathematical Biology Special Interest Group Meeting

The annual one-day Mathematical Biology Special Interest Group (MBSIG) Workshop will be held after the main ANZIAM Conference. The Workshop will feature talks from five invited speakers and the Winner of the Student Best Paper Prize, and a panel discussion on interdisciplinary research in mathematics and biology.

- *When* : Friday 13 February 2026, 9.00am – 2.15pm
- *Where* : The Mathematical Science Institute (Building 145) at ANU
- *Cost* : \$50 AUD (you must have registered through the conference registration system before 19 January.)

## 4.13 Engineering Mathematics Workshop

The Engineering Mathematics Group is holding a one-day workshop at the Australian National University on the day after the ANZIAM Conference in Canberra on Friday 13 February 2026. We welcome submissions of abstracts for short talks.

Important Information:

- When: 9.45am – 3pm, Friday February 13, 2026
- Where: Australian National University, Canberra
- Abstract Submission: Please send abstracts to Louise Olsen-Kettle: Email: [lolsenkettle@swin.edu.au](mailto:lolsenkettle@swin.edu.au) Registration: \$50 (includes catering).
- Invited Speakers:
  - Chris Tisdell (UNSW)
  - Fangbao Tian (UNSW)

## 5 Conference Events at a glance

Time	Sun 8 Feb	Mon 9 Feb	Tue 10 Feb	Wed 11 Feb	Thu 12 Feb
8:30		Opening ceremony	Announcements	Announcements	Announcements
8:40		Plenary Duenez-Guzman	Plenary Flegg	Plenary Tam	Plenary Silber
9:00					
9:20		Contributed talks	Contributed talks	Contributed talks	Contributed talks
9:40					
10:00		Morning tea	Morning tea	Morning tea	Morning tea
10:20		Contributed talks	Contributed talks	Contributed talks	Plenary Baeumer (11.30am - 12.30pm)
10:40					
11:00		Contributed talks	Contributed talks	Contributed talks	Closing ceremony (12.30pm - 1pm)
11:20					
11:40	LGBTQIA+ lunch	Lunch	WIMSIG lunch	Lunch	Lunch
12:00	Registration opens	ANZIAM Exec	Free afternoon	Lunch	Lunch
12:20					
12:40					
13:00					
13:20					
13:40					
14:00					
14:20					
14:40					
15:00					
15:20	Plenary Bassom	Plenary Ramanan			
15:40	Contributed talks				
16:00	Afternoon tea	Afternoon tea			
16:20	Contributed talks	Plenary Thamwattana (3pm - 4pm)			
16:40		Panel discussion (4.30pm - 5pm)			
17:00	Welcome reception	Student social event	ANZIAM AGM	Conference dinner	
17:20					
17:40					
18:00					
18:30	Welcome reception	Student social event	ANZIAM AGM	Conference dinner	
19:30					
20:30					
21:30					
22:30	Welcome reception	Student social event	ANZIAM Exec	Conference dinner	

## 6 Plenary lectures

Each plenary talk will be 40 minutes long with an additional 10 minutes for questions.

<b>Day</b>	<b>Time</b>	<b>Plenary speaker</b>	<b>Talk title</b>
MON	9:00	Jennifer Flegg	Multiscale modelling in biology, with applications to malaria
MON	14:00	Andrew Bassom	The not-so-simple stability of a time-periodic flow
TUE	8:40	Edgar Duéñez-Guzmán	The emergence of bias: lessons from tabula rasa learning agents
WED	8:40	Matthew Tam	Distributed Convex Optimisation
WED	14:00	Kavita Ramanan	Understanding high-dimensional stochastic dynamics on realistic networks
WED	15:30	Natalie Thamwattana	Clogging in granular assembly when treating acidic groundwater
THU	8:40	Mary Silber	Resilience in drylands: landscape-scale, self-organized vegetation patterns
THU	11:30	Boris Baeumer	Randomising time: A Foray into a Non-Markovian World

## 7 Contributed talks

The program is shown on the following pages. The duration of each contributed talk will be 15 minutes with an additional five minutes for questions and changeover. Student talks are marked with asterisks.

### Monday 9 February (morning session)

8:30 – 9:00	<b>Conference opening</b>				
9:00 – 9:50	<b>Plenary talk : Jennifer Flegg</b> Multiscale modelling in biology, with applications to malaria <i>Chair : Mary Myerscough</i>				
	<b>Room 1 and 2</b> <i>Chair :</i> <i>Douglas Brumley</i>	<b>Room 3</b> <i>Chair:</i> <i>Courtney Quinn</i>	<b>Room 4</b> <i>Chair:</i> <i>Steve Taylor</i>	<b>Room 5</b> <i>Chair :</i> <i>Stephen Davis</i>	<b>Room 6</b> <i>Chair : Catherine</i> <i>Sweatman</i>
10:00 – 10:20	<b>Jessica Crawshaw</b> The whole baby PK/PD model of anti-VEGF therapy that big pharma doesn't want you to see	<b>David John Warwick Simpson</b> Peculiar periodicity paths and other patterns in the parameter space of piecewise-linear maps.	<b>David Jenkins</b> Coke reactivity with CO <sub>2</sub> and H <sub>2</sub> O and impacts on coke microstructure	<b>Ruarai Tobin*</b> The role of antibody-mediated immunity in shaping the seasonality of respiratory viruses	<b>Aidan Patterson*</b> An Agent-Based Approach to Modelling Antimicrobial Interactions with Bacterial Populations
10:20 – 10:40	<b>Mary Myerscough</b> Heart attacks and strokes; why (mathematical) cholesterol matters	<b>Samuel Bolduc-St-Aubin*</b> From Resonance to Chaos in a Delayed-Feedback Model of ENSO	<b>Edward Bissaker</b> Quantitative approaches to improve coal blending models for high-performance ironmaking	<b>Sadia Tasnim Sristy*</b> Epidemiology of Plasmodium knowlesi Malaria in Sabah, Malaysia (2009-2023): case incidence and diagnostic performance	<b>Cecilia Olivesi*</b> An agent-based and blood flow model of vascularisation in endometriotic lesions.
10:40 – 11:00	<b>Tristen Jackson*</b> Mathematical Modelling of Retinal Immune Cells During Inflammation		<b>Matthias Kabel</b> Rapid Offline Training for Deep Material Networks: A Displacement-Based Laminate Formulation and Novel Sampling for Fatigue Modeling	<b>James McCaw</b> Linking intra-host parasite dynamics, transmission and epidemiological dynamics to evaluate the public health utility of alternative drug regimens for Falciparum malaria.	<b>Neda Khodabakhsh Joniani*</b> Intercellular Forces Regulate Stratification and Turnover in a Two-Layer Corneal Epithelium
11:00 – 11:20	<b>Morning tea - Grand Ballroom</b>				

## Monday 9 February (morning session continued)

	<b>Room 1 and 2</b> <i>Chair :</i> <i>Maud El-Hachem</i>	<b>Room 3</b> <i>Chair:</i> <i>David Simpson</i>	<b>Room 4</b> <i>Chair:</i> <i>David Jenkins</i>	<b>Room 5</b> <i>Chair :</i> <i>Bronwyn Hajek</i>	<b>Room 6</b> <i>Chair :</i> <i>Larry Forbes</i>
11:20 – 11:40	<b>Matthew Simpson</b> Data-informed model reduction for inference and prediction from non-identifiable models	<b>Joe Steele*</b> Modelling and Analysis of Semiconductor Lasers Subject to Fibre Bragg Grating Feedback	<b>Pierluigi Cesana</b> Equilibrium and Interaction Regimes in Mixed Disclination–Dislocation Systems	<b>Jacob Gentner*</b> Evolution of complex singularities for Burgers' equation with discontinuous initial conditions	<b>Matthew Walker*</b> A viscoplastic deposit on a vibrating plate
11:40 – 12:00	<b>Alexander Browning</b> Prediction, uncertainty, and treatment design in cancer through mathematical modelling	<b>Bernd Krauskopf</b> Devil's terraces in a conceptual climate model with periodic forcing	<b>Teresa Heiss-Synak</b> New Method for Analyzing The Hole-Structure of a Crystal: Merge Trees of Periodic Filtrations	<b>Scott McCue</b> Exponential asymptotics, dispersive waves and the KdV equation	<b>Siluvai Antony Selvan</b> Inertial particle focusing in the duct with elliptical centreline
12:00 – 12:20	<b>David Warne James</b> Efficient simulation and inference of non-Markovian stochastic biochemical reaction networks	<b>Hinke Osinga</b> Phase resetting in a system of coupled Van der Pol oscillators	<b>Kenji Kajiwara</b> Truss Structures with Mechanical Optimality Generated by Integrable Discrete Holomorphic Functions	<b>Dave Smith</b> Linearized KdV on the line with a metric graph defect	<b>Andrey Pototsky</b> The effect of self-induced Marangoni flow on polar-nematic waves in active-matter systems
12:20 – 12:40	<b>Elijah Foo*</b> Reliable model selection of ODE models in face of parameter non-identifiability	<b>Davide Papapicco*</b> Inferring critical transitions from timeseries	<b>Eloise Tredenick</b> Mathematical Modelling of bilayer cathodes that enable fast charging of lithium-ion batteries	<b>Philip Broadbridge</b> Circular solution of a Navier-Stokes system for compressible fluid with temperature-dependent viscosity	<b>Fiaz Ur Rehman*</b> Flow dynamics of a viscous fluid above granular material on a slope
12:40 – 13:00	<b>Patrick Grant</b> Predicting Buckling in Epithelial Monolayers	<b>Courtney Rose Quinn</b> Rate-induced tipping and delay: examples and challenges through the lens of a paleoclimate model		<b>John H Knight</b> Periodic soil heat flow – the phase difference between maximum heat flux and maximum temperature	<b>Liam Morrow</b> A finite element based solver for studying large scale groundwater dynamics
13:00 – 14:00	<b>Lunch - Grand Ballroom</b> <b>LGBTQIA+ and allies Lunch - Level 5</b>				

## Monday 9 February (afternoon session)

14:00 – 15:00	<b>Plenary talk : Andrew Bassom</b> <a href="#">The not-so-simple stability of a time-periodic flow</a> <i>Chair : Luke Bennetts</i>				
	<b>Room 1 and 2</b> <i>Chair :</i> <i>Dietmar Oelz</i>	<b>Room 3</b> <i>Chair :</i> <i>Eloise Tredenick</i>	<b>Room 4</b> <i>Chair :</i> <i>Stuart Johnston</i>	<b>Room 5</b> <i>Chair :</i> <i>Roslyn Hickson</i>	<b>Room 6</b> <i>Chair :</i> <i>Hritika Gupta</i>
15:00 – 15:20	<b>Graeme Wake</b> <a href="#">Unusual nonlocal calculus assists cancer cell growth treatments</a>	<b>Andrew Axelsen*</b> <a href="#">Covariations between persistent synoptic features and Antarctic sea ice via unsupervised regression learning</a>	<b>Robert Cope</b> <a href="#">Topological summary statistics for Approximate Bayesian Computation on Collective Motion models</a>	<b>Matthew Berry</b> <a href="#">Effectiveness of dose-sparing against Mpox</a>	<b>Ashley Hanson*</b> <a href="#">The Price of Anarchy in Strategic Queues</a>
15:20 – 15:40	<b>Ying Xie</b> <a href="#">A Novel Secondary Therapeutic Strategy Combined with Antihistamines Based on Morphology-Defined Endotypes of Chronic Spontaneous Urticaria</a>	<b>Noa Kraitzman</b> <a href="#">Bounding Thermal Transport in Sea Ice</a>	<b>Yvonne Stokes</b> <a href="#">Modelling chemical signalling on fertilisation of the mammalian cumulus-oocyte complex.</a>	<b>Rebecca Chisholm</b> <a href="#">Modelling the impact of mass drug administration on human onchocerciasis when there is sub-optimal response of parasites to treatment</a>	<b>Peter Gerrard Taylor</b> <a href="#">Strategic Customer Behaviour in an M/M/1 Feedback Queue</a>
15:40 – 16:00	<b>Afternoon tea - Grand Ballroom</b>				

## Monday 9 February (afternoon session continued)

	<b>Room 1 and 2</b> <i>Chair :</i> <i>Alex Tam</i>	<b>Room 3</b> <i>Chair:</i> <i>Bernd Krauskopf</i>	<b>Room 4</b> <i>Chair:</i> <i>Phil Broadbridge</i>	<b>Room 5</b> <i>Chair :</i> <i>Rebecca Chisholm</i>	<b>Room 6</b> <i>Chair :</i> <i>Peter Heiss Synak</i>
16:00 – 16:20	<b>Brendan Florio</b> Tendon adaptation through damage and repair mechanisms	<b>Ofri Adiv*</b> Classification of Energy Surfaces in a Coupled Light-Matter System	<b>Justin Tzou</b> Curved vegetation stripes on a curved terrain	<b>Oliver Eales</b> Developing on-farm management strategies for reducing H5N1 transmission in dairy cattle	<b>Sergey A. Suslov</b> Flow in a rotating film: how far can one go without DNS?
16:20 – 16:40	<b>Kailas Honasoge*</b> Evolutionary game theory for better environmental decisions	<b>Priya Subramanian</b> Mode interactions between two length scales	<b>Michael Dallaston</b> The Fisher-KPP equation with mass conservation at a moving boundary	<b>Michael Plank</b> Is it over yet? Estimation of end-of-outbreak probabilities	<b>Sami Al-Izzi</b> Symmetry based methods of active mechanics
16:40 – 17:00	<b>Kevin Downard</b> Prime Amino Acids - Number Theory Meets Protein Evolution	<b>Siwen Deng</b> A non-radially symmetric MFPT problem with a small trap undergoing small amplitude rotation	<b>David Plenty*</b> Non-Classical Symmetries and Non-Lie Solutions with Biological Growth Rate Functions to a Class of Nonlinear Reaction-Diffusion Equations	<b>Vincent Lomas*</b> Integrating Ethnic Heterogeneity into Infectious Disease Transmission Models	<b>Caitriona Lightbody*</b> Draw resonance in micro-structured optical fibre fabrication
17:00 – 17:20	<b>Maud El-Hachem</b> From whales to mosquitoes: delayed recruitment models with density dependence and competition	<b>Kaname Matsue</b> A Design of Distributed Controllers for Linear Nonautonomous Multi-Agent Systems	<b>Yoshimichi Hayashi*</b> Mathematical Modeling and Numerical Simulation of Localized Bioconvection	<b>Daniel Longmuir*</b> When hosts gather: how extreme seasonal aggregation affects epidemiological outcomes	<b>Peter Heiss Synak</b> Taming Non-Manifold Meshes and Simulating Bubbles with Colours
17:20 – 17:40	<b>Sungrim Seirin-Lee</b> Decoding Cell Geometry: Insights from Mathematical Modeling Based on Imaging Data	<b>Fumito Mori</b> Coupling estimation in synchronized oscillators using spike timing data	<b>Christopher Lustri</b> Stokes' Phenomenon Within a Small-Time Boundary Layer	<b>Matt Ryan</b> How BaD can it be? Model identifiability for behaviour and disease models	<b>Tharindi Thathsarani Amaratunge Achchige*</b> Pattern formation in ionic liquids: two-phase thin-film model
18:30 – 20:30	<b>Student Social Event - Grease Monkey, 19 Lonsdale St, Braddon</b>				

## Tuesday 10 February (morning session)

8:30 – 8:40	<b>Announcements</b>			
8:40 – 9:40	<b>Plenary talk : Edgar Duéñez-Guzmán</b> <i>The emergence of bias: lessons from tabula rasa learning agents</i> <i>Chair : Cecilia González-Tokman</i>			
	<b>Room 1 and 2</b> <i>Chair :</i> <i>Jessica Crawshaw</i>	<b>Room 3</b> <i>Chair:</i>	<b>Room 4</b> <i>Chair:</i> <i>Noa Kraitzman</i>	<b>Room 5</b> <i>Chair :</i> <i>Scott McCue</i>
9:40 – 10:00	<b>Elizabeth Ivory*</b> <i>Evaluating <i>Plasmodium vivax</i> treatment policies: an economic perspective</i>	<b>Tim Bourke*</b> <i>Calculus Without Limits</i>	<b>Parul Tiwari</b> <i>Data Driven Assessment of Climate Change Impacts on Water Quality Index in Tukituki River</i>	<b>Luke Bennetts</b> <i>Cloaking flexural-gravity waves in an anisotropic plate floating on shallow water</i>
10:00 – 10:20	<b>Komal Komal*</b> <i>Modeling the effects of cross immunity and control measures on competitive dynamics of variants in the USA, UK, and Brazil</i>	<b>Pascal R. Buenzli</b> <i>Making mathematics engaging and affordable to today's students transitioning into engineering degrees with day jobs and math anxiety</i>	<b>Chantelle Blachut</b> <i>The influence of ignition pattern and fuel load on Vorticity-driven Lateral Spread</i>	<b>Ben Wilks</b> <i>Water wave scattering by a rectangular anisotropic elastic plate</i>
10:20 – 10:40	<b>Olle Ponten*</b> <i>Three-dimensional characteristics of the movements of dinoflagellates; a multi-disciplinary investigation</i>	<b>Michael Lydeamore</b> <i>Gamifying data visualisation: Teaching ggplot2 through competitive code golf</i>	<b>Liam Blake*</b> <i>A Gaussian mixture filter with splitting for data assimilation</i>	<b>Edward Hinton</b> <i>Optimal profiles in confined and non-Newtonian flows</i>
10:40 – 11:00	<b>Pengxing Cao</b> <i>Using mathematical models to study the drivers of severe outcomes during influenza virus infections</i>	<b>Adriana Zanca</b> <i>Gender representation at mathematics conferences in Australia: all a matter of perception?</i>	<b>Heather Jenkins</b> <i>A signal-processing method for analysing how orchard production systems affect ground-level microclimate</i>	<b>Larry Forbes</b> <i>The Fluid Mechanics of your Morning Coffee</i>
11:00 – 11:20	<b>Morning tea - Grand Ballroom</b>			

## Tuesday 10 February (morning session continued)

	<b>Room 1 and 2</b> <i>Chair :</i> <i>Matthew Simpson</i>	<b>Room 3</b> <i>Chair:</i> <i>Matthew Tam</i>	<b>Room 4</b> <i>Chair:</i>	<b>Room 5</b> <i>Chair :</i> <i>Michael Plank</i>
11:20 – 11:40	<b>Tsubasa Sukekawa</b> Imaging Data-based Model Description Combining Optimal Transport and Phase-field Model	<b>Luz Pascal*</b> Developing new technologies in changing environments	<b>Llewyn Randall*</b> The numerical challenges of modelling the erosion of complex landform	<b>Thao P. Le</b> Simulating emergency animal disease outbreaks and response: development and outcomes
11:40 – 12:00	<b>Alex Tam</b> Thin-film modelling and parameter optimisation for biofilms	<b>Maria Kleshnina</b> Cooperating on networks: inequality and social structure	<b>Melanie Roberts</b> The potential for re-vegetation to mitigate climate change effects on gully growth in Queensland.	<b>Isobel Abell*</b> Communicating real-time modelling during emergency animal disease outbreaks, a qualitative analysis
12:00 – 12:20	<b>Douglas Brumley</b> Unravelling three-dimensional active transport by ciliary arrays on coral surfaces	<b>David Ceddia*</b> Optimization of Athletic Performance with Injury Risk	<b>Lucy Dowdell*</b> The Abundance Constraints Approach: A New Method to Ensemble Ecosystem Modelling for Large Networks	<b>Christopher Baker</b> Enhancing rapid decision-support for emergency animal disease outbreaks
12:20 – 12:40	<b>Thisaakhya Jayakody*</b> A time-inhomogeneous Markovian model for demography of women	<b>Liam Timms*</b> A decentralized algorithm with application to min-max problems	<b>Grace Robinson*</b> What should grow where? optimising human land use	<b>Hannah McGregor*</b> Mathematical Modelling of Pertussis Dynamics and Impact In Aotearoa New Zealand
12:40 – 13:00	<b>Taiga Kadowaki*</b> A Markov Process-Based Mathematical Model of Vascular Stenosis Formation and Treatment	<b>Kaniz Fatema*</b> DC optimization method for solving reverse convex programming	<b>Liam Gibson*</b> Quantifying land use change in low country Waitaha-region braidplains	<b>Pantea Pooladvand</b> Why Cultural Change Repeatedly Triggers Disease Emergence
13:00 – 14:00	<b>Lunch - Room 6</b> <b>WIMSIG lunch - Grand Ballroom</b>			
14:00 – 19:30	<b>Free afternoon</b>			
19:30 – 21:30	<b>ANZIAM AGM - Room 1 and 2</b>			
21:30 – 22:30	<b>ANZIAM Executive meeting - Room 1 and 2</b>			

## Wednesday 11 February (morning session)

8:40 – 9:40	<b>Plenary talk : Matthew Tam</b> Distributed Convex Optimisation <i>Chair : Peter Taylor</i>				
	<b>Room 1 and 2</b> <i>Chair :</i> Adelle Coster	<b>Room 3</b> <i>Chair:</i> Tony Roberts	<b>Room 4</b> <i>Chair:</i> Elise Mills	<b>Room 5</b> <i>Chair :</i> Richard Creswell	<b>Room 6</b> <i>Chair :</i> Brendan Florio
9:40 – 10:00	<b>Kota Nishi*</b> Habituation Mechanism in the True Slime Mold via a Spatially Discretized Reaction-Diffusion Model	<b>Kajanthan Shiymasuntharam*</b> Efficient Pricing of American Bond Options under CIR Stochastic Volatility via Coordinate Transformation	<b>Anuradha Dhananjanie Priyadarshana Alankara Dewage*</b> Assessing the sensitivity of explainable AI for marine ecology	<b>Bhavya Srivastava*</b> Modelling the Impact of Bedaquiline-Based Treatment Regimens on Tuberculosis Drug Resistance	<b>Celia Dowling*</b> Exploring how population heterogeneity improves collective navigation performance towards a moving target
10:00 – 10:20	<b>Michael Pan</b> Mathematical approaches for refining metabolic maps of <i>Leishmania</i> parasites	<b>Dhruv Goel*</b> Impact of Liquidity Risk in Portfolio Selection: A New Approach	<b>Amanda Salpadoru*</b> Parameter estimation and identifiability analysis of stability and tipping points in lake ecosystems	<b>Yilei Huang*</b> How Does Short-Term Broad Immunity Influence Antigenic Evolutionary Dynamics in Influenza?	<b>Cooper Maher*</b> Modelling the population dynamics of arbovirus vector <i>Culex Annulirostris</i> in southeastern Australia
10:20 – 10:40	<b>Alys Rachel Clark</b> Mathematical models of whole placenta nutrient transfer, structure versus transport properties	<b>Hritika Gupta</b> Regime-switching stochastic models for temperature forecasting and weather derivative pricing	<b>Jordan Holdorf*</b> Optimising Restoration Portfolios Through Spatial Heterogeneity and Climate Risk	<b>Weisheng Wang*</b> Canine Ehrlichiosis in Northern Australia: A Sensitivity and Elasticity Analysis of R0	<b>Jinghao Chen</b> Modeling heterogeneous PIEZO1 activity in collective keratinocyte migration
10:40 – 11:00	<b>Brock Sherlock*</b> A Surrogate Model for Efficient Inference of GLUT4 Translocation	<b>Michael Groom</b> EON: Entropy-optimal networks	<b>Matthew Adams</b> Simulating ecosystem networks of large size: Current approaches and future challenges	<b>Stephen Davis</b> Mathematical models of tick-borne pathogens and the unique contact patterns of ticks	<b>Joshua Forrest</b> Chemokine Combinations in Macrophage Chemotaxis
11:00 – 11:20	<b>Morning tea - Grand Ballroom</b>				

## Wednesday 11 February (morning session continued)

	<b>Room 1 and 2</b> <i>Chair :</i> <i>David Warne</i>	<b>Room 3</b> <i>Chair:</i> <i>Maria Kleshnina</i>	<b>Room 4</b> <i>Chair:</i> <i>Judy Bunder</i>	<b>Room 5</b> <i>Chair :</i> <i>Sergey Suslov</i>	<b>Room 6</b> <i>Chair :</i> <i>Alex Browning</i>
11:20 – 11:40	<b>Catherine Hassell Sweatman</b> Applications of a model of type 2 diabetes	<b>David Stanford</b> Non-preemptive Priority Queues with Distinct Customer Selection Rules	<b>Bakhodirzhon Siddikov</b> Application of the Approximation Theory in the Field of Magnetic Refrigeration	<b>Caitlin Anchor*</b> Two-dimensional topography estimation from noisy free surface data	<b>Lata Paea*</b> Exploring the Dynamics of Uterine Smooth Muscle Fibre Contraction Using Agent-Based Modelling.
11:40 – 12:00	<b>Catheryn Gray</b> Mathematical Modelling of Porin-Mediated Glucose Transport in <i>Klebsiella pneumoniae</i>	<b>Chathurika Srimali Gunasekara Ekanayaka Mudiyansele*</b> Optimizing Two Consecutive Shutdown Maintenance Scheduling with Endogenous Uncertainty	<b>Tess O'Brien</b> Hunting Dragons: non-unique parameter estimates arise from numerical error in longitudinal models	<b>Elizabeth Jagerma*</b> Computation of Three Dimensional Free Surface Flow Inverse Problems Using Boundary Integrals	<b>Liuhaoyu*</b> Modelling trophoblast bilayer turnover: an agent-based modelling approach
12:00 – 12:20	<b>Dietmar Oelz</b> Mechanochemical Axis Formation in Hydra Spheroids	<b>Nataliya Togobrytska</b> Modelling and Optimisation of Melt Pool Geometry in Metal Additive Manufacturing	<b>Alexander Labovsky</b> Recursive Correction in Fluid Flow Modeling	<b>Xinyi Yang*</b> Resolving two-body hydrodynamic interactions between microswimmers	<b>Lyndon Koens</b> Quantitative methods for motion trace fossils
12:20 – 12:40	<b>Faith Sawers*</b> Modelling Initial Calcification in Atherosclerosis	<b>Ryo Fujie</b> Controlling between-group pay-off differences with zero-determinant strategies	<b>Elizabeth Harris</b> Improvement on the Worst-Case Runtime for Calculating Minimum Volume Covering Ellipsoids	<b>Mike Meylan</b> Linear Wave Scattering by a Beach	<b>Matthew Mack*</b> Two Acts in One: The Actin Model That Couldn't, And The One That... Could?
12:40 – 13:00	<b>Haruka Suga*</b> A Simplified Mathematical Model for Estimating Stenosis Treatment Time in Catheter Procedures		<b>Nawal Alsubaie*</b> Three points inequalities for Riemann-Stieltjes integral of Lipschitzian or bounded variation integrands and integrators of $r$ -Hölder type with applications	<b>Andreas Heinecke</b> Duality for frames - and application to MRA wavelet construction	<b>Muhammad Asim Farooq*</b> Modelling inter-clonal cooperation in epithelial carcinogenesis using spatial models
13:00 – 14:00	<b>Lunch - Grand Ballroom</b>				

## Wednesday 11 February (afternoon session)

- 14:00 – 15:00 **Plenary talk : Kavita Ramanan**  
 Understanding high-dimensional stochastic dynamics on realistic networks  
*Chair : Ilze Ziedins*
- 15:00 – 15:30 **Afternoon tea - Grand Ballroom**
- 15:30 – 16:30 **Plenary talk : Natalie Thamwattana**  
 Clogging in granular assembly when treating acidic groundwater  
*Chair : Scott McCue*
- 16:30 – 17:00 **Panel discussion - what do employers want in an applied mathematics graduate?**  
 Alex Kalliotis (DSTG), Trudy Green (eWater), Mahdi Parsa (DAFF), Jennifer Flegg (University of Melbourne)
- 18:30 – 21:30 **Conference dinner - Room 1 and 2**
- 21:30 – 22:30 **Conference dinner continues - Howling Moon, level 6**

## Thursday 12 February (morning session)

- 8:40 – 9:40 **Plenary talk : Mary Silber**  
 Resilience in drylands: landscape-scale, self-organized vegetation patterns  
*Chair : Hinke Osinga*
- |               | <b>Room 1 and 2</b>   | <b>Room 3</b>   | <b>Room 4</b>   | <b>Room 5</b>   | <b>Room 6</b>   |
|---------------|---|---|---|---|---|
|               | <i>Chair :</i><br><i>Alys Clark</i>   | <i>Chair:</i><br><i>Edward Bissaker</i>   | <i>Chair:</i><br><i>Simon Clarke</i>  | <i>Chair :</i><br><i>Melanie Roberts</i>  | <i>Chair :</i><br><i>Pantea Pooladvand</i>  |
| 9:40 – 10:00  | <b>Thomas Williams</b><br>Modelling the growing outer membrane of Gram-negative bacteria                                | <b>Patrick Grant</b><br>Timber in Trouble: Predicting Failure in Engineered Wood Products                 | <b>Zachary James Wegert</b><br>Next-generation computational design with unfitted finite elements and automatic shape differentiation | <b>Winston Sweatman</b><br>Birds, Fish and Finding Nice Shapes  | <b>Roslyn Hickson</b><br>Estimation of <i>Aedes albopictus</i> abundance based on a dengue outbreak in Australia                              |
| 10:00 – 10:20 | <b>Stuart Johnston</b><br>Quantifying biological heterogeneity in nano-engineered particle-cell interaction experiments | <b>Edoardo Fabbrini</b><br>A Variational Formulation for Plane-Strain Elasticity with Topological Defects | <b>Paul Charles Leopardi</b><br>Rigorous numerical analysis in the age of vibe coding: case studies                                   | <b>Elise Mills</b><br>Thermal performance curve models calibrated to ecological data using Sequential Monte Carlo sampling: an application to Antarctic moss photosynthesis | <b>Richard Creswell</b><br>Inferring duration of seropositivity from infection prevalence and seroprevalence survey data                      |
| 10:20 – 10:40 | <b>Adrienne Jenner</b><br>In silico trial of a cancer treatment combing a virus and an immune "magnet"                  | <b>Daniel J Netherwood</b><br>Towards a model for growth-induced wrinkling in thin elastic sheets         | <b>Judith Bunder</b><br>Efficient 'equation-free' simulations of elastic beams  | <b>Tomoharu Suda</b><br>From time series to dynamics: a categorical perspective   | <b>Tiffany Leung</b><br>Estimating the impact of a school-based live-attenuated influenza vaccination program in Australia: a modelling study |
| 10:40 – 11:00 | <b>Ryan Murphy</b><br>A coarse-grained mathematical model for colorectal crypt dynamics                                 | <b>Steve Taylor</b><br>MINZ, protein power drinks and traffic flow  | <b>Kazuki Koga</b><br>Weak comparisons between compact surfaces   | <b>Gary Froyland</b><br>Optimising climate sensitivity: an El-Nino Southern Oscillation case study  | <b>Alexandra Hogan</b><br>Mathematical modelling of endemic SARS-CoV-2 transmission and implications for vaccination strategies               |
- 11:00 – 11:30 **Morning tea - Grand Ballroom**
- 11:30 – 12:30 **Plenary talk : Boris Baeumer**  
 Randomising time: A Foray into a Non-Markovian World  
*Chair : Yvonne Stokes*
- 12:30 – 13:00 **Closing ceremony**
- 13:00 – 14:00 **Lunch - Grand Ballroom**

## 8 Abstracts

### 8.1 Invited talks

#### **Randomising time: A Foray into a Non-Markovian World**

Boris Baeumer  
University of Otago

**Author(s):** Boris Baeumer

**Time:** Thu 11:30

**Place:** Room 1 and 2

We give an overview and develop non-local-in-time differential equation (or Volterra integral equations) from the ground up. We highlight common modelling mistakes and thus the importance of comparing the analytical solution against realisations of the model. ([Back](#))

#### **The not-so-simple stability of a time-periodic flow**

Andrew Bassom  
University of Tasmania

**Author(s):** Andrew Bassom

**Time:** Mon 14:00

**Place:** Room 1 and 2

It has long been recognised that time-periodic flows occur in numerous contexts including within nature, engineering and biology. Given these applications, it is perhaps surprising how little is known about the stability properties of some of these flows. In this talk I will introduce the notion of fluid stability and how we might use it to assess the properties of periodic motions. In particular, we consider the stability of the so-called flat Stokes layer. This is the motion induced within a fluid layer above a plate which is made to oscillate within its own plane. The flat Stokes layer has attracted much study over the years, not least because it is one of the relatively few exact solutions of the Navier-Stokes equations. Perhaps surprisingly, even the simplest linear stability analysis of the flow proves to be somewhat of a challenge, and the results obtained are very different to the predictions arising from related experiments. Plausible explanations for this discrepancy are outlined. ([Back](#))

#### **The emergence of bias: lessons from tabula rasa learning agents**

Edgar Duéñez-Guzmán  
Gibran AI

**Author(s):** Edgar Duéñez-Guzmán

**Time:** Tue 08:40

**Place:** Room 1 and 2

AI is revolutionising many scientific fields and finding applications in virtually all industries. Despite continued interest in the fairness of these systems, and some progress towards the creation of safe and beneficial AI, there is still poor understanding about how biases emerge between interacting and learning agents. In this talk we will discuss how tabula rasa agents develop bias towards co-players even in the absence of intrinsic differences. We will examine how learning agents involved in interactions with partner choice can learn to use perceptual characteristics of others instead of the task-relevant characteristics when making decisions, leading to suboptimal behaviour. Fortunately, simple perceptual interventions are able to ameliorate (and in some cases, eliminate) the bias. ([Back](#))

## Multiscale modelling in biology, with applications to malaria

Jennifer Flegg

The University of Melbourne

**Author(s):** Jennifer Flegg

**Time:** Mon 09:00

**Place:** Room 1 and 2

Multiscale processes are fundamental to biological systems, yet remain challenging to model and simulate in a coherent mathematical framework. This talk focuses on the development of multiscale models for the transmission of *Plasmodium vivax* malaria, a disease characterised by complex within-host dynamics arising from dormant liver-stage parasites (hypnozoites) and their interaction with population-level disease transmission. I'll present several models that embed stochastic within-host hypnozoite dynamics into population-level transmission models, allowing key biological features such as relapse, treatment, and mass drug administration to be captured. Extensions to stochastic population models quantify extinction probabilities under intervention, while spatially structured models illustrate how human movement shapes transmission dynamics. To support these increasingly detailed models, I also introduce a hybrid simulation method that adaptively couples discrete stochastic and continuous deterministic dynamics across scales. Together, these multiscale modelling and simulation approaches can provide insight into vivax malaria transmission and control, and offer a general framework applicable to other biological systems where stochasticity, spatial structure, and multiple interacting scales are essential. ([Back](#))

## Understanding high-dimensional stochastic dynamics on realistic networks

Kavita Ramanan

Brown University

**Author(s):** Kavita Ramanan

**Time:** Wed 14:00

**Place:** Room 1 and 2

A variety of phenomena in engineering, operations research, epidemiology and machine learning are modelled as large collections of randomly evolving particles that interact locally with respect to an underlying network. Classical analysis, falling under the rubric of mean-field theory, has mostly focused on the case when the network is dense. However, most real-world networks are sparse and often random. We survey recently developed theory that provides tractable descriptions of the typical behavior of interacting systems on large sparse and heterogeneous random networks, and illustrate how it can be used to glean insight into specific applications. ([Back](#))

## Resilience in drylands: landscape-scale, self-organized vegetation patterns

Mary Silber  
University of Chicago

**Author(s):** Mary Silber

**Time:** Thu 08:40

**Place:** Room 1 and 2

A stunning example of spontaneous pattern formation occurs in certain drylands around the globe, including Australia. Regularly-spaced bands of vegetation alternate with bands of bare soil on a landscape-scale, making these patterns easily detected via remote sensing satellites. The vegetation bands are oriented transverse to gentle elevation grades, and, interestingly, can slowly migrate uphill. Natural questions to ask are what sets the spacing of these bands and what sets the upslope migration speed? We use a conceptual consumer-resource modeling framework to investigate these questions, where vegetation is the consumer and soil water is the resource. Key nonlinear feedbacks between these components lead to pattern formation under aridity stress. A challenging feature of drylands is that the water inputs to the system are not continuous; they are the result of rare storm events, which are unpredictable and highly variable. Our model captures the disparity of timescales, and the stochasticity, by treating rain events as random impulses to the system. The soil water and vegetation then evolve together, between storms, on the slow ecosystem timescale via simple deterministic reaction-diffusion PDEs. This modeling framework allows us to explore how changes to storm characteristics, such as their frequency and intensity, might impact the ecosystem. New pattern formation questions arise as we probe the resilience of these remarkable ecosystems under changing rainfall patterns. ([Back](#))

## Distributed Convex Optimisation

Matthew Tam  
The University of Melbourne

**Author(s):** Matthew Tam

**Time:** Wed 08:40

**Place:** Room 1 and 2

Distributed optimisation is concerned with algorithms for solving optimisation problem which can exploit distributed computing architectures, such as those used in high performance and cluster computing. Within this paradigm, the basic computing model consists of a fleet of "simple" devices, connected via some network topology, which work collaboratively to solve a complex-structured problem. Each device has some partial knowledge of the problem which is private to that particular device and the ability to do computational work. In order to exploit the power of distributed computing architectures, algorithms for distributed optimisation must carefully balance local computation and inter-device communication, whilst still ensuring convergence to solutions. In this talk, I will give an overview of challenges in distributed convex optimisation as well as report on some recent developments including those related to distributed min-max problems. ([Back](#))

## Clogging in granular assembly when treating acidic groundwater

Natalie Thamwattana  
The University of Newcastle

**Author(s):** Natalie Thamwattana

**Time:** Wed 15:30

**Place:** Room 1 and 2

Acid sulphate soils are commonly found around the coastal regions of Australia. When exposed to air during flood-mitigation drainage, construction or excavation activities (e.g. coal mining), pyrite ( $\text{FeS}_2$ ) in these soils can rapidly oxidise to produce sulfuric acid, leading to groundwater contamination and causing acid drainage in underground coal mines. To treat acidic groundwater, permeable reactive barriers (PRBs) or subsurface treatment zone filled with alkaline materials (e.g. crushed recycled concrete, ash, blast-furnace slag, or calcitic limestone) are introduced as a filter to remove contaminants and neutralise acidity caused by pyrite oxidation. However, accumulation of chemical precipitates and bacterial growth can clog PRBs reducing their porosity, which in turn reduces their longevity and functionality. Clogging in PRBs can also impair the performance of piezometers, which are used to measure pore-water pressure in the ground.

In this talk, I will discuss the modelling of clogging in PRBs, focusing on the accumulation of bacteria and the coating of reactive aggregates with chemical precipitates, as well as the resulting effects on porosity and PRB performance over time. I will also present a model for determining pore-water pressure and examine how clogging influences piezometer accuracy. Finally, I will discuss a study of machine learning (ML) models for predicting pH changes in groundwater treated by PRBs, highlighting the advantages and limitations of both ML approaches and mathematical models for assessing groundwater acidity. ([Back](#))

## 8.2 Contributed talks

### Communicating real-time modelling during emergency animal disease outbreaks, a qualitative analysis

Isobel Abell\*

The University of Melbourne

**Author(s):** Isobel Abell

**Time:** Tue 11:40

**Place:** Room 5

Mathematical modelling can provide key evidence to support such decision-making, helping understand unfolding outbreak dynamics for diseases and pests. However, to best support outbreak response, mathematical modelling must be communicated effectively to be understood and interpreted by decision-makers as intended. Understanding how modelling can be most effectively designed for and communicated to decision-makers is therefore crucial to effectively support real-time decision-making.

In this talk, I will discuss how we ran simulation exercises focused on incorporating real-time modelling into the decision-making pipeline to understand the role of modelling to support EAD outbreak management and practice its implementation. I will present a qualitative analysis of the data gathered from participants, namely simulation exercise transcripts and survey data. Overall, this work provides insight into decision-maker perceptions of modelling and highlights key contextual factors that decision-makers consider when being presented with modelling. By identifying the practicalities of decision-making and the information that decision-makers are looking for, I will discuss how this work informs how modellers can build useful models and effectively communicate results to support decision-making. ([Back](#))

### Simulating ecosystem networks of large size: Current approaches and future challenges

Matthew Adams

Queensland University of Technology

**Author(s):** Matthew Adams, Lucy Dowdell, Lauren Deegan, Jenney Chen, Maria Kleshnina, Gloria Monsalve-Bravo, Scott Sisson, Christopher Drovandi

**Time:** Wed 10:40

**Place:** Room 4

Natural ecosystems can contain numerous species that interact with each other in a network. However, standard ecological models predict that ecosystems with a large number of species should collapse. This discrepancy, resolvable with ecological theories of how ecosystems developed stochastically over time, nevertheless has, up until recently, limited practical simulation of ecosystem networks to approximately less than 15 species.

This talk presents a summary of our recent work to efficiently simulate ecosystem networks with many interacting species. Starting with “ensemble ecosystem modelling” (EEM), we have since introduced Bayesian inference approaches which cut down the computation time by several orders, allowing simulation of networks of up to 20 or so species. More recent work (in preparation) exploits the linear structure of the equilibrium conditions for standard ecological models (such as generalised Lotka-Volterra and multispecies Gompertz) to further reduce computation time, permitting a potential drastic advance to efficiently simulate 100 or more species. This fascinating work has thus far utilised ordinary differential equation models, Bayesian inference, linear algebra and linear programming, to resolve a simulation problem of significant interest in community ecology. ([Back](#))

## Classification of Energy Surfaces in a Coupled Light-Matter System

Ofri Adiv\*

The University of Auckland

**Author(s):** Ofri Adiv, Bernd Krauskopf, Neil Broderick, Scott Parkins

**Time:** Mon 16:00

**Place:** Room 3

We investigate the behaviour of a pair of atomic ensembles confined to optical cavities which couple to one another through the exchange of light. Such atom-cavity systems are widely studied in quantum optics and have parallels to models from other fields, e.g., condensed-matter and nuclear physics.

Our analysis is rooted in dynamical systems theory and centers around the ordinary differential equations (ODEs) that govern the time evolution of quantum expectation values. These equations conserve the total energy of the system, thereby constraining trajectories to lying on two-dimensional surfaces of constant energy. We fully classify the topology of these surfaces, which depends both on the energy and the system parameters. Furthermore, we relate this classification to the system's equilibria and the bifurcations they undergo. ([Back](#))

## Oscillatory Snaking in a Nonlinear Epidemic Reaction–Diffusion Model with Quadratic Incidence

Fahad Saif Al Saadi

Military Technological College

**Author(s):** Fahad Al Saadi, Thoraya N Alharthi and Mustafa Kutlu

**Time:**

**Place:**

We uncover a novel class of spatiotemporal patterns—oscillatory snaking—in a non-linear epidemic reaction–diffusion model with quadratic (mass-action) incidence. The model admits a positive endemic equilibrium capable of both Hopf (temporal) and Turing (spatial) instabilities. Through linear stability analysis, we rigorously identify the parameter regimes where these bifurcations intersect, setting the stage for complex dynamics. Employing numerical continuation and direct simulations, we systematically compute nonlinear branches of both steady and time-periodic localized states. Our results reveal a striking homoclinic snaking structure: localized infection outbreaks organize into intertwined steady-state branches, while a family of time-periodic “breather” solutions emerges via subcritical Hopf bifurcations and connects into a characteristic oscillatory snaking diagram. Extending the analysis to two spatial dimensions confirms the persistence of these phenomena. Epidemiologically, our findings suggest the possibility of persistent, spatially localized, and temporally oscillating epidemic hotspots—structures that may underpin recurrent flare-ups in real populations. This work bridges classical pattern formation theory with spatial epidemic modeling and demonstrates how the interplay between diffusion-driven and oscillatory instabilities can yield a rich tapestry of multistable, localized outbreak dynamics ([Back](#))

## Symmetry based methods of active mechanics

Sami Al-Izzi  
UNSW Sydney

**Author(s):** Sami Al-Izzi

**Time:** Mon 16:20

**Place:** Room 6

Active matter is the study of materials which, in contrast to fluids and solids typically described in continuum mechanics, consume some form of stored energy in order to perform mechanical work. Examples include biological tissues, cell membranes and engineered robotic metamaterials. The hidden degrees of freedom involved in this energy consumption mean that their effective continuum theories are not described by the minimization of some energy functional or dissipation functional and as such their mechanical stress tensors are not limited to the form of classical continuum theories.

Here I will discuss symmetry based approaches using the theory of Lie algebras and differential geometry for constructing such stress tensors and discuss how this can be applied to odd elastic materials, chiral active membranes, and how these extensions can modify the dynamics of proteins in the curved lipid membranes of living cells. ([Back](#))

## Assessing the sensitivity of explainable AI for marine ecology

Anuradha Dhananjanie Priyadarshana Alankara Dewage\*  
Queensland University of Technology

**Author(s):** Anuradha Dhananjanie, Helen Thompson, Julie Vercelloni, David J. Warne

**Time:** Wed 09:40

**Place:** Room 4

Machine learning (ML) is regularly being used in ecological modelling to improve predictive accuracy, yet its lack of explainability remains a key challenge in the ecology space. This lack of explainability is a major limitation for the use of ML methods to identify drivers of ecosystem decline. To address this explainability problem, various approaches have been proposed in an emerging subfield of ML research known as explainable AI (xAI). However, practical applications of xAI techniques in environmental or ecological studies are limited and reliance on a single ML model is commonly seen in ecology literature. We explore the efficacy of the state-of-the-art explainability technique known as Shapley additive explanation (SHAP) for obtaining ecological insights from ML-based models using examples from coral reef ecology. We generated coral cover spatio-temporal data using a synthetic data generating software, *Synthos*, that is developed by the Australian Institute of Marine Science (AIMS). We developed a measure of SHAP discrepancy between model explanations and use this to demonstrate variation in explainability across different ML approaches with implications for reef management. This analysis framework is not limited to marine space, but is potentially generalisable and applicable across different ecosystems. We conclude that caution is required in relying on a single ML model to identify the drivers of coral decline and plan management and conservation interventions. ([Back](#))

### Three points inequalities for Riemann-Stieltjes integral of Lipschitzian or bounded variation integrands and integrators of $r$ -Hölder type with applications

Nawal Alsubaie\*  
Victoria University

**Author(s):** Nawal Alsubaie, Silvestru Sever Dragomir, Gabriele Sorrentino

**Time:** Wed 12:40

**Place:** Room 4

In this paper we obtained some new simple error bounds in approximating the Riemann-Stieltjes integral  $\int_a^b f(t) du(t)$  by the use of three points rule

$$[u(b) - u((1-\lambda)x + \lambda b)]f(b) + [u(va + (1-v)x) - u(a)]f(a) \\ + [u((1-\lambda)x + \lambda b) - u(va + (1-v)x)]f(x),$$

where  $\lambda, v \in [0, 1]$ ,  $x \in [a, b]$  and assuming that the function  $f$  is  $L$ -Lipschitzian or of bounded variation and  $u$  is  $r$ - $H$ -Hölder type on  $[a, b]$ . The important case of weighted integrals is considered, compounding quadrature rules are provided and applications for approximation of Fourier transforms on finite intervals are also given. ([Back](#))

### Pattern formation in ionic liquids: two-phase thin-film model

Tharindi Thathsarani Amarathunge Achchige\*  
Adelaide University

**Author(s):** Tharindi Amarathunge, Bronwyn Hajek, Alex Tam, Marta Krasowska

**Time:** Mon 17:20

**Place:** Room 6

Precursor films formed by ionic liquids have excellent lubrication properties for high-end applications. These precursor films create patterns on different substrates, and the effectiveness of a lubricating layer depends on the pattern they form. This study develops a two-phase thin-film model to analyse patterns formed by one or more ionic liquids on a substrate. In this talk, I present a linear stability analysis and some numerical results to explore how liquid-liquid and liquid-substrate interactions influence precursor film patterns. ([Back](#))

### Two-dimensional topography estimation from noisy free surface data

Caitlin Anchor\*  
University of Adelaide

**Author(s):** Caitlin Anchor, Benjamin Binder, Trent Mattner, John Maclean

**Time:** Wed 11:20

**Place:** Room 5

The inverse topography problem involves estimating the bottom topography from measurements of a free surface. In this talk, we present a weakly nonlinear approach to address this problem using the forced Korteweg-de Vries (fKdV) equation for steady two-dimensional free surface flow of an inviscid incompressible fluid corrupted by measurement noise. Owing to the presence of noise, there is a compounding inverse solution error as the grid resolution is refined due to numerical differentiation and so a linear least squares regression method is proposed as a way to mitigate noise on the surface. A closed-form expression for the mean and variance of the inverse solutions is derived to examine the uncertainty of our topographic predictions. We demonstrate the adaptability of our contributions to six classical flow types, providing a systematic method for quantifying the uncertainty in topographic estimates that is insightful and interpretable. ([Back](#))

## Covariations between persistent synoptic features and Antarctic sea ice via unsupervised regression learning

Andrew Axelsen\*  
University of Tasmania

**Author(s):** Andrew Axelsen, Terence O’Kane, Courtney Quinn, Andrew Bassom

**Time:** Mon 15:00

**Place:** Room 3

During the past decade, a succession of anomalous events in sea ice concentration has suggested that perhaps a shift in the overall dynamics of sea ice in the Antarctic region is underway. We attempt to gain fresh insight into how atmospheric drivers may play a role in these anomalous events, particularly their influence on Antarctic sea ice retreat in the warmer months, by studying coupled atmosphere-sea ice variability during the 2016-2017, 2021-2022, and 2023 low sea ice concentration years. In this analysis, we first construct a reduced-order model from reanalysed observations based on a well-developed machine learning algorithm incorporating coupling across subsystems, namely the atmosphere and sea ice. We then extract the background persistent events occurring throughout the years of interest by employing non-stationary transition matrix methods to the resultant temporal sequence of states. These events are analysed by considering the associated surface pressure, winds, temperature, and sea ice concentration. Compared to existing methods, this non-stationary method captures events over varying temporal scales, providing additional insights that uniform fixed period averages (e.g. monthly means) and most existing methods (e.g. most statistical methods) cannot obtain.

In this talk, I introduce this non-stationary method and apply it to three select years, discussing the qualitative influence of the extracted atmospheric patterns at surface level on Antarctic sea ice development. ([Back](#))

## Enhancing rapid decision-support for emergency animal disease outbreaks

Christopher Baker  
The University of Melbourne

**Author(s):** Chris Baker

**Time:** Tue 12:00

**Place:** Room 5

Enhancing rapid decision-support for emergency animal disease outbreaks is a two year project aiming to improve Australia’s capacity and capability for using mathematical modelling in emergency response. As this two-year project draws to a close, I will reflect on challenges and successes, and review progress and future opportunities. ([Back](#))

## Cloaking flexural–gravity waves in an anisotropic plate floating on shallow water

Luke Bennetts

The University of Melbourne

**Author(s):** Sophie Thery, Malte A Peter, Luke G Bennetts, Sebastian Guenneau

**Time:** Tue 09:40

**Place:** Room 5

The principle of cloaking has been developed and applied to different types of waves. We consider the application in the context of flexural–gravity waves on shallow water in order to reduce the wave force on an object. The parameters of the plate used to create a cloak in the vicinity of the object are found by applying a space transformation method to the wave-propagation equation. The governing equation of a Kirchhoff–Love plate is generally not shape-invariant, which traditionally induces error terms in the (thus approximate) use of the space transformation method. First deriving the equations of motion for the shallow-water–fully anisotropic plate system by a variational principle, we extend the transformation method to anisotropic plates and show that for every change of coordinates there exists a class of anisotropic plates such that the equation of motion is shape-invariant. Further, we consider examples in which the wave force on and the scattering by a rigid bottom-mounted vertical cylinder are reduced when surrounded by a floating plate with a cloaking region having material parameters computed by the presented method and we illustrate an approximate case by simulations. ([Back](#))

## Effectiveness of dose-sparing against Mpox

Matthew Berry

University of New South Wales

**Author(s):** Matthew Berry, Miles Davenport, David Khoury

**Time:** Mon 15:00

**Place:** Room 5

Vaccination has proved a highly effective tool for providing protection against many viral infections. During the global outbreak of Mpox, vaccination was used as a tool to mitigate the number of infections. Due to limited vaccines available, questions surrounding how best to deploy these vaccines have been raised in East and Central Africa. Such limitations have raised the question of whether one dose of the vaccine provides sufficient protection. Using predictions of vaccine effectiveness, using antibody data, we can assess how effective different this dose sparing strategy performs over time. ([Back](#))

## Quantitative approaches to improve coal blending models for high-performance ironmaking

Edward Bissaker  
The University of Newcastle

**Author(s):** Edward Bissaker

**Time:** Mon 10:20

**Place:** Room 4

Metallurgical coke is a porous, solid carbon fuel used within blast furnaces to facilitate iron production. High-quality coke must achieve a delicate balance between strength and reactivity for efficient blast furnace operation, and these factors are closely tied to the coke's microstructure and composition. While significant research has investigated the links between coke properties and blast furnace performance, little is known about how optimal coke microstructures may differ from those currently manufactured, underscoring the need for further exploration. Coke microstructure is highly variable and comprises features at various length scales, reflecting differences between the inert-derived maceral and reactive-derived material components. The complexity of these features and the preexisting links to parent coal chemistry suggest that an investigation of coke microstructure could lead to improved understanding of how to manufacture coke with target properties. Understanding and optimising coke microstructure is a crucial step toward producing coke that meets the requirements of high-efficiency iron-making technologies, ultimately contributing to more sustainable and effective iron-making. This talk will outline a novel framework of quantitative techniques and mathematical models utilising three-dimensional statistics to characterise and link coke microstructure features directly to selected industry-standard coke quality measures, such as tumble drum tests. We demonstrate how the statistical representations can be optimised to provide deeper insight into the microstructural changes that can enhance a target coke quality measure, and how mathematical models can be used to provide insight into the manufacturing process (coal blending) required for future high-performance cokes. ([Back](#))

## The influence of ignition pattern and fuel load on Vorticity-driven Lateral Spread

Chantelle Blachut  
University of New South Wales Canberra

**Author(s):** Chantelle Blachut, Jason J. Sharples, Kevin K.W. Cheung, Dennis Del Favero

**Time:** Tue 10:00

**Place:** Room 4

Bushfires in the vicinity of ridgelines can evolve and escalate in unusual and unexpected ways. Such fires can for example, spread laterally along a ridge in the direction almost perpendicular to prevailing winds. Here we focus on real and idealised WRF-SFIRE simulations of these so-called Vorticity-driven Lateral Spread (VLS) events. Given the serious risk to lives and property posed by such extreme fire events, this work aims at an early assessment of feasible VLS mitigation strategies. ([Back](#))

## A Gaussian mixture filter with splitting for data assimilation

Liam Blake \*  
Adelaide University

**Author(s):** Liam Blake, John Maclean, Sanjeeva Balasuriya

**Time:** Tue 10:20

**Place:** Room 4

Data assimilation combines model output with observational data to obtain improved forecasts and is fundamental to numerical weather prediction and many other scientific applications. However, existing approaches are often limited by either computational limitations and degeneracy issues or rely on restrictive assumptions such as linear dynamics and Gaussian error statistics. Gaussian mixture models are a class of methods that can represent nonlinear state distributions while still having some of the advantages of linear-based methods. There are many such methods, referred to as filters, but these are all either static - not allowing the number of components to change - or rely on computationally intractable measures of nonlinearity or statistical notions. We propose a Gaussian mixture filter with a component splitting scheme based on a rigorous understanding of how model error is propagated, which is a connection that is yet to be unexploited. Our method has shown promising results on low-dimensional examples. We also posit that our method may be extended to an ensemble framework, allowing application to the extremely high-dimensional models used in operational weather prediction. ([Back](#))

## From Resonance to Chaos in a Delayed-Feedback Model of ENSO

Samuel Bolduc-St-Aubin \*  
The University of Auckland

**Author(s):** Samuel Bolduc-St-Aubin, Priya Subramanian, Bernd Krauskopf

**Time:** Mon 10:20

**Place:** Room 3

The El Niño–Southern Oscillation (ENSO) is responsible for irregular warming and cooling episodes in the equatorial Pacific Ocean. ENSO models come at many levels of complexity. We focus on conceptual ENSO models, which condense the essential physics into a manageable mathematical forms to facilitate intuition-building and the analysis with advanced techniques. The delayed-action oscillator (DAO) paradigm explains El Niño events as arising from a time-delayed negative feedback loop driven by the propagation of large-scale oceanic waves. Motivated by the observation that ENSO events tend to lock to the seasonal cycle, we consider a periodically forced version of the very first DAO model of ENSO due to Suarez and Schopf. We present a detailed bifurcation analysis of this periodically forced delay differential equation. Due to the infinite dimensional nature of DDEs, this ENSO model features a rich range of dynamical behaviours, including flows on invariant tori and chaotic dynamics. By varying the forcing frequency, we show that the observed chaotic dynamics arises through period-doubling cascades and overlapping resonance tongues. With a new method to compute the rotation number on stable invariant tori for DDEs, we examine precisely how this overlap unfolds. ([Back](#))

## Calculus Without Limits

Tim Bourke \*  
The Australian National University

**Author(s):** Tim Bourke

**Time:** Tue 09:40

**Place:** Room 3

The project "Calculus Without Limits" will study both maths major and non-maths major student attitudes and engagement with technical topics in first year calculus courses at ANU Mathematical Sciences Institute (MSI) before and after lectures, tutorials and group activities which will present and teach alternative approaches to these topics, based mainly on the work of the Indian "Kerala school" which used calculus and related mathematical techniques in the fifteenth century for astronomical purposes. ([Back](#))

### **Circular solution of a Navier-Stokes system for compressible fluid with temperature-dependent viscosity**

Philip Broadbridge  
La Trobe University

**Author(s):** Phil Broadbridge

**Time:** Mon 12:20

**Place:** Room 5

Couette flow can be solved for a compressible Newtonian fluid with temperature-dependent viscosity and thermal conductivity. That turns out to be one of the very few known exact solutions of the Navier-Stokes system for coupled mass density, momentum, temperature, pressure and entropy. Amenable temperature-dependence will be investigated. ([Back](#))

### **Prediction, uncertainty, and treatment design in cancer through mathematical modelling**

Alexander Browning  
The University of Melbourne

**Author(s):** Alexander Paul Browning

**Time:** Mon 11:40

**Place:** Room 1 and 2

Cancer is a highly variable disease. Mathematical models are often proposed as a tool to aid our understanding of the underlying dynamics, to predict treatment outcomes, and guide clinical decision-making. Hindering effective use of models is the sparsity of clinical measurements juxtaposed with the complexity required by mathematical models to produce the full range of patient responses. In this talk, we develop a minimal mathematical model capable of producing a wide gamut of patient responses. We then develop a statistical learning algorithm to leverage a cohort of existing clinical data to produce a predictive model of tumour volume progression that accounts for both patient to patient variability, and prediction uncertainty. We conclude by discussing new approaches to deal with other sources of uncertainty in the practical application of models to inform treatment in cancer. ([Back](#))

## Unravelling three-dimensional active transport by ciliary arrays on coral surfaces

Douglas Brumley  
The University of Melbourne

**Author(s):** S.A. Selvan, C.O. Pacherras, M. Kühl, A. Butler, M.S. Dhillon, L.L. Blackall, P.W. Duck, D. Pihler-Puzović, D.R. Brumley

**Time:** Tue 12:00

**Place:** Room 1 and 2

Ciliary flows promote nutrient exchange, protect organisms from debris and pathogens, and assist in environmental regulation. However, investigating the role of ciliary heterogeneity has proven challenging, since typical approaches overlook microscale flow features. Using several coral species as exemplar systems for ciliary transport, we develop a multiscale mathematical model which resolves flows across several orders of magnitude and calculates associated mass transport. Our experiments, which measure fluid flows and spatial oxygen profiles, reveal strong agreement with model predictions. The framework unravels how the spatial arrangement of cilia critically modulates transport processes in living systems, particularly under low-flow conditions. ([Back](#))

## Making mathematics engaging and affordable to today's students transitioning into engineering degrees with day jobs and math anxiety

Pascal R. Buenzli  
Queensland University of Technology

**Author(s):** Pascal R. Buenzli

**Time:** Tue 10:00

**Place:** Room 3

Australia is set to face a shortage of skilled STEM workforce, and mathematics is in crisis. Enrolments in higher and intermediate mathematics in Australian high schools are at historic lows. These record-low participation rates are fuelled by increasing math anxiety, resulting in poor mathematical skills and disengagement among first-year Engineering students. At the same time, most students balance study with paid employment, limiting the time they can devote to their learning. Limited study capacity, math anxiety, weak prior knowledge, and limited formative feedback at universities result in disengagement, high attrition rates, and strong incentives to outsource learning to assessment subcontractors such as Chegg or AI.

In this talk, I will present my attempts at making mathematics engaging and affordable in a large first-year Engineering Mathematics subject of about 1000 students. 'Affordability' is a key pragmatic consideration from a student perspective for deciding whether an academic outcome is within their reach in terms of the efforts, resources, or time commitment required to achieve it. I will present an overview of a successful model based on weekly structured worksheet submissions to drive student engagement and success, and weekly engagement campaigns targeting students at risk of disengaging. These approaches help students remain engaged, reduce assessment (somewhat paradoxically), remunerate student work with regular tokens of success, and provide weekly feedback to students on their learning, all the while remaining within a total marking budget of 40min/student, including exams. Over 2022–2025, these innovations have hugely improved student satisfaction, student attrition, and closed-book exam grades. ([Back](#))

## Efficient 'equation-free' simulations of elastic beams

Judith Bunder  
Adelaide University

**Author(s):** Judy Bunder, Thien Tran-Duc, Tony Roberts

**Time:** Thu 10:20

**Place:** Room 4

Elastic beams with multiscale structures are designed to have novel properties, such as high mechanical strengths or physical and chemical properties for specific applications. However, full numerical simulations of these complex materials are prohibitively expensive, both in compute time and data storage requirements. For practical simulations it is usually necessary to apply an approximation method that homogenises the microscale structure and provides a solution at the macroscale relevant to the given application. Here we introduce equation-free modeling for efficient simulations of beam dynamics. Equation-free multiscale modeling is a purely computational scheme that provides efficient macroscale simulations of complex materials by solving the exact microscale equation, but only in small, sparse 'patches' distributed evenly across the domain. Interpolations between patches accurately support the macroscale dynamics. ([Back](#))

## Using mathematical models to study the drivers of severe outcomes during influenza virus infections

Pengxing Cao  
The University of Melbourne

**Author(s):** Pengxing Cao

**Time:** Tue 10:40

**Place:** Room 1 and 2

Influenza virus infection can result in either a mild illness that is usually resolved quickly or a severe infection that lasts much longer and may lead to death. However, the causes of these divergent outcomes remain unclear. Experimental studies have not identified a single driver that can fully explain the clinical observations. Instead, the interplay among a broad range of host responses, such as macrophages, inflammatory cytokines, NK cells, CD8 T cells, neutralizing antibodies, and a recently identified enzyme, OLAH, have been suggested to play a role. In collaboration with virologists and immunologists from the Peter Doherty Institute, we have been developing mathematical models (ordinary differential equation models) to study the dynamics of immune responses and the mechanisms driving severe infection outcomes. In this talk, I will focus on presenting (1) how the models were developed and justified using experimental data to incrementally improve our understanding of viral infection dynamics, and (2) how the infection dynamics can be related to disease severity. I hope our work will be of interest not only to researchers working on within-host modelling but also to those considering incorporating within-host dynamics into population-level transmission models. ([Back](#))

## Optimization of Athletic Performance with Injury Risk

David Ceddia\*

The University of Melbourne

**Author(s):** David Ceddia

**Time:** Tue 12:00

**Place:** Room 3

Optimising performance sounds simple: train harder and get better. In reality, athletes walk a fine line: too little training and they stagnate; too much and they break.

This talk introduces a mathematical framework for training-load optimisation that treats injury risk as an intrinsic component of the system rather than an external constraint. Starting from the Banister et al. Fitness Fatigue impulse-response model, we examine why naive optimisation produces unrealistic train-maximally solutions, and how incorporating probabilistic tolerance models (Weibull, Log-Normal, Gamma) leads to emergent behaviours such as moderation, gradual progression, and physiologically meaningful periodisation.

The discussion highlights how seemingly small modelling choices, such as linear versus multiplicative dynamics or different formulations of hazard and conditional failure, can dramatically reshape optimal strategies. Along the way, we address a surprising question: What mathematical structure makes rest days arise naturally in an optimisation model? ([Back](#))

## Equilibrium and Interaction Regimes in Mixed Disclination–Dislocation Systems

Pierluigi Cesana

Kyushu University

**Author(s):** Pierluigi Cesana, Marco Morandotti, Aldo Sambo

**Time:** Mon 11:20

**Place:** Room 4

We investigate the dynamics and equilibrium configurations of systems containing both disclinations and dislocations. By identifying distinct mechanical regimes, we characterize how these defects interact and influence one another. The analysis is nontrivial: disclinations represent rotational asymmetries and possess finite energy, whereas dislocations are genuine topological defects with infinite energy. Through asymptotic analysis and an appropriate rescaling of the governing equations, we uncover a regime in which a system composed of a single disclination and a single dislocation exhibits an effective interaction. In this regime, the combined system behaves as though the dislocation itself acquires the characteristics of a disclination. ([Back](#))

## Modeling heterogeneous PIEZO1 activity in collective keratinocyte migration

Jinghao Chen  
Kyoto University

**Author(s):** Jinghao Chen, Medha M. Pathak, John S. Lowengrub

**Time:** Wed 10:20

**Place:** Room 6

During wound reepithelialization, the mechanically-activated ion channel PIEZO1 has been identified as an inhibitory factor in healing, regulating wound edge retraction and disrupting coordinated directionality in the collective migration of keratinocytes. PIEZO1 activity is heterogeneous among cells, but the impact of mixtures with varying PIEZO1 levels on wound healing remains poorly understood. In this study, we developed an integrative two-dimensional mathematical model to investigate the wound closure dynamics of mixtures containing two distinct cell types. Each cell type is governed by its own set of equations and parameters, reflecting its specific PIEZO1 activity level and interacting through mechanisms including cell-cell adhesion, volume-filling effects, and wound edge retraction. Simulations reveal that cells with higher PIEZO1 activity are generally underrepresented at the wound edge, correlating with increased retraction and negative curvature. Furthermore, mixing mutually repulsive cells accelerates wound closure more effectively than homogeneous populations while preserving wound shape regularity. ([Back](#))

## Modelling the impact of mass drug administration on human onchocerciasis when there is sub-optimal response of parasites to treatment

Rebecca Chisholm  
La Trobe University

**Author(s):** Rebecca H. Chisholm, Shilian Xu, Kwadwo K Frempong, Himal Shrestha, Joseph Kwadwo Larbi Opare, Odame D. Asiedu, Ernest Mensah, Makedonka Mitreva, Warwick N Grant, Shannon M Hedtke

**Time:** Mon 15:20

**Place:** Room 5

An estimated 246 million people are at risk of infection with the parasite *O. volvulus*, which causes river blindness or onchocerciasis. These parasites are transmitted by blackflies in the genus *Simulium* and mature into fertile adult worms in a person's skin. The morbidity and economic impact of onchocerciasis have motivated large-scale elimination programs in sub-Saharan Africa, using mass drug administration of ivermectin (MDAi).

Both stochastic, individual-based models and deterministic, population-based models have been used to inform the design of adopted MDAi strategies. However, none of these models have incorporated "sub-optimal response" (SOR) of *O. volvulus* to ivermectin, despite evidence that this is playing an increasingly important role in the ongoing persistence of onchocerciasis in many communities in sub-Saharan Africa.

In this presentation, I will describe how we adapted a deterministic *O. volvulus* transmission model to incorporate variable response to treatment. Our model accounts for two, heritable *O. volvulus* phenotypes with different responses to the effects of ivermectin: female good-responding worms (GR) with a slow return to fertility following exposure to ivermectin and female SOR worms that recover fertility much faster. The model is parameterised to reflect *O. volvulus* transmission and MDAi frequency and coverage in one of the first communities where SOR was identified—Asubende, Ghana—which underwent periods of annual and biannual MDAi from 1987-2024. I will compare predictions from our model under this real scenario with those from an analogously parameterised model that does not account for variable parasite response to ivermectin. I will then contrast the predictions of both models under different assumptions about the level of endemic transmission prior to MDAi, the frequency and duration of MDAi, and under the theoretical impact of MDA of a newly-available drug, moxidectin, with superior effects on both the GR and SOR phenotypes.

Our work illustrates the necessity for models to more accurately reflect the biological complexity of *O. volvulus*, particularly if they are being used to inform MDAi program design, and supports the need to acknowledge the potential problems of SOR when making decisions about how to optimally achieve elimination. ([Back](#))

## Mathematical models of whole placenta nutrient transfer, structure versus transport properties

Alys Rachel Clark  
The University of Auckland

**Author(s):** Alys Rachel Clark, Carl Whitfield, Igor Chernyavsky, Jo James

**Time:** Wed 10:20

**Place:** Room 1 and 2

Each of us grew a unique organ before we were born. This organ, the placenta, was responsible for nourishing us until it was time for delivery. It is a temporary organ, with a lifespan of just 9 months, and as such there are considerable variations in anatomy between placentas. This includes variation in the size and shape of the placenta, and in the branching network of blood vessels that resides within it. Several clinical studies have aimed to address the impact of this anatomical variation, linking blood vessel anatomy to stillbirth, poor growth, diabetes, and neurodevelopmental implications. However, given the variation in the population, it is not clear what features of the placenta matter functionally.

I will present a mathematical model of nutrient transport from maternal blood to fetal blood, which takes into account the anatomical structure of the placenta. This model uses theoretical framework in which we link exchange capacity of a capillary bed within the placenta to two structural parameters (the total capillary length and a characteristic diffusion length scale) and characteristics of the nutrient in question (diffusion coefficient, advective transport capacity). The model predicts that that vascular network heterogeneity is likely a major contributor to inadequate exchange, and relate our modelling to clinical data which show damage to the placental tissue that may be characterised during a pathological examination of the placenta. ([Back](#))

## Topological summary statistics for Approximate Bayesian Computation on Collective Motion models

Robert Cope  
University of New England

**Author(s):** Beatrice Bleile, Robert Cope, Masoud Ganji, Vera Miloslavskaya, David Paul, Timothy Schaerf, Mitchell Welch

**Time:** Mon 15:00

**Place:** Room 4

Collective motion models describe rules for the movement and interactions of individuals (typically animals) within a group. Different group-level behaviours emerge from different regions of the model parameter space. Because these models involve the positions of many individuals over time, simulated data from them are quite high dimensional, and so carefully chosen summary statistics are needed to apply inference methods like Approximate Bayesian Computation. We will describe some preliminary work testing a range of summary statistics for this purpose, including both statistics that are often used to characterise behaviour of these collective motion models, and statistics based on spatiotemporal persistent topology. ([Back](#))

**The whole baby PK/PD model of anti-VEGF therapy that big pharma doesn't want you to see**

Jessica Crawshaw

Queensland University of Technology

**Author(s):** Jessica Crawshaw

**Time:** Mon 10:00

**Place:** Room 1 and 2

Anti-VEGF therapy has recently been approved by the FDA to prevent the progression of retinopathy of prematurity (ROP; a leading cause of childhood blindness) and preserve vision in preterm newborns. Following injection, it is known that these drugs leave the eye and enter the systemic circulation, however, from there, the distribution of these drugs to the developing organs is unknown. Whilst uptake of these growth-suppressing drugs into the developing organs is denied by the financially interested parties, emerging evidence from animal studies shows that anti-VEGF agents reach the brain, lungs, and heart, and have been shown to restrict the growth of these organs. Clinicians currently have no quantitative way to predict these risks or adjust treatment accordingly, let alone make an informed decision on whether this is the best treatment option.

In this talk, I will present a data-driven organ-level pharmacokinetic/pharmacodynamic model of intravitreal aflibercept therapy in growing preterm newborns babies with ROP to predict the drug load experienced by key developing organs. I use a Bayesian approach to validate the model against clinical data and predict a physiologically plausible parameter space in preterm newborns. We then use this model to predict optimal dosing, timing and monitoring. ([Back](#))

## Inferring duration of seropositivity from infection prevalence and seroprevalence survey data

Richard Creswell  
The University of Melbourne

**Author(s):** Richard Creswell  
**Time:** Thu 10:00  
**Place:** Room 6

Seroprevalence surveys assess a random sample of individuals from a population for the presence of antibodies indicating a history of infection. Seroprevalence surveys are valuable sources of information about the spread of a disease, including for learning the true number of new infections arising over time, which typically differs substantially from the number of reported cases. However, using the output of a seroprevalence survey to learn about the number and timing of new infections is contingent of knowledge of the probability of an individual testing positive for antibodies as a function of time since their infection onset, referred to as a seropositivity curve. In this work, we consider an infectious disease surveillance framework in which infection prevalence surveys, seroprevalence surveys, and reported cases are available, but reported cases underestimate true infections (in an unknown, time-varying way), and precise prior knowledge of the seropositivity curve is not available. Using agent based simulations of an underlying epidemic and simulations of the disease surveillance observation processes, we investigate the ability to learn the seropositivity curve. We present a Bayesian inference approach for joint inference of the true number of infections and the seropositivity curve. We show that when infection prevalence and seroprevalence survey data are numerous enough, it is possible to learn accurate and precise seropositivity profiles, which in turn enable superior inference of the true number of infections over time. These results contribute to the efficient design of infectious disease surveillance strategies that seek to maximize the information which can be obtained from limited surveillance resources. ([Back](#))

## The Fisher-KPP equation with mass conservation at a moving boundary

Michael Dallaston  
Queensland University of Technology

**Author(s):** Georgia Weatherley, Adrienne Jenner, Michael Dallaston  
**Time:** Mon 16:20  
**Place:** Room 4

The Fisher-KPP equation is the canonical example of a reaction-diffusion equation that results in travelling waves, with a range of applications in mathematical biology. To model the biologically realistic presence of sharp interfaces between populations, moving boundaries may be included. In the past, such moving boundaries have been modelled using a Stefan-like condition, in which the velocity of the boundary is dependent on a flux of cells into (or out of) that boundary. We consider the dynamics of the Fisher-KPP equation with a moving boundary velocity that is instead a function of the local population, but does not involve any flux into the boundary. This condition is more appropriate in cases where populations may move an interface (e.g. through deposition, or degradation of an existing environment) without being consumed by this process. A wide range of behaviour is obtained, including regimes where multiple stable and unstable travelling wave solutions exist, as well as runaway population blow-up. ([Back](#))

## Mathematical models of tick-borne pathogens and the unique contact patterns of ticks

Stephen Davis  
RMIT University

**Author(s):** Stephen A. Davis, Simon P. Johnstone-Robertson, Cooper Maher, Kevin Bown and Maria A. Diuk-Wasser

**Time:** Wed 10:40

**Place:** Room 5

Mathematical models of tick-borne disease either emphasise the discrete nature of tick bites - ticks only bite once per life stage - or treat all processes as continuous and consist of a set of differential equations. With either approach the contact patterns of ticks that determine opportunities for horizontal transmission are challenging to include. Aggregation of host-seeking ticks of the genus *Ixodes* exemplifies a well-known pattern in parasitology, often referred to as the 80-20 rule, where a majority of parasites are found on a small subset of hosts. Coincident co-aggregation of the two immature life-stages, the larval and nymphal stages, is a separate phenomenon that occurs when host-seeking larvae and nymphs aggregate on the same subset of individual hosts at the same time. This broadly benefits the transmission and maintenance of tick-borne pathogens by increasing the opportunities for horizontal transmission to occur from infected nymphs to susceptible larvae. We provide a simple seasonal measure of coincident co-aggregation, which we denote  $\epsilon_{co}$ , that can be calculated from tick burden count data commonly collected during longitudinal small mammal trapping studies. This is effectively a correction factor to  $R_0$  where  $\epsilon_{co} > 1$  indicates that co-aggregation is boosting  $R_0$ . Bootstrapping can be used to generate confidence intervals; if these do not include 1 then there is strong support in the data that co-aggregation is occurring. We apply our method to four data sets from the United Kingdom, Japan and North America. For all four data sets and for the three *Ixodes* vectors - *I. scapularis*, *I. ricinus* and *I. persulcatus* - most responsible for human cases of tick-borne disease we observe significant but modest coincident co-aggregation where  $\epsilon_{co} \sim 2$ . Uncertainty in  $\epsilon_{co}$  depends heavily on the number of hosts in the trapping data having at least 1 nymph rather than the numbers of hosts, larvae or nymphs.

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## A non-radially symmetric MFPT problem with a small trap undergoing small amplitude rotation

Siwen Deng  
Kyoto University

**Author(s):** Siwen Deng, Justin Tzou, Shuangquan Xie

**Time:** Mon 16:40

**Place:** Room 3

We consider the mean first passage time (MFPT) on a two-dimensional disk with a diffusing particle. The particle performs a random walk in the unit disk centered at the origin, which contains a circular trap of radius  $0 < \varepsilon \ll 1$  whose center at  $\mathbf{x}_{\text{trap}}(z) = (x_c + \mu \cos \omega z, \mu \sin \omega z)$ , where  $(x_c, 0)$  is the center of rotation with  $x_c \in [0, 1)$  and  $\mu < \varepsilon \ll 1$  is the trap's rotation amplitude. We treat time  $z \in [0, 2\pi]$  as a third spatial coordinate. Therefore, a three-dimensional mixed boundary value problem on a cylinder that governs the search time is derived. In this way, we expand a 2-dimensional MFPT problem into a 3-dimensional one. A matched asymptotic analysis of this problem reveals the existence of a critical frequency  $\omega_c$  such that the expected search time is less than the one with a stationary particle when  $\omega > \omega_c$ . We obtain a simple condition which gives the optimal trap oscillating frequency in terms of the gradient of the regular part of a Green's function. Additionally, we explore the variance of critical frequency along the change of  $x_c$ . To confirm our theoretical solution, we use the boundary integral method and finite element method of the associated partial differential equations to validate our asymptotic results. ([Back](#))

## The Abundance Constraints Approach: A New Method to Ensemble Ecosystem Modelling for Large Networks

Lucy Dowdell\*  
Queensland University of Technology

**Author(s):** Lucy Dowdell

**Time:** Tue 12:00

**Place:** Room 4

Ensemble Ecosystem Modelling (EEM) is a powerful algorithm to simulate ecosystem networks where all species coexist. EEM randomly samples values for the parameters of the Generalised Lotka-Volterra equation and the samples are accepted if they meet two conditions: (1) feasibility and (2) stability. Once an ensemble of plausible ecosystems is generated using EEM, scenario testing can be performed to predict the lasting impacts of human interventions on ecosystem networks and will help inform ecosystem management decisions. A challenge with utilising EEM is the high computation time required for ecosystems with a large number of species due to the low acceptance rate of samples. In an effort to increase the acceptance rate, the abundance constraints approach is proposed. The abundance constraints approach shifts the sampled parameters such that it meets feasibility automatically and therefore, only needs to satisfy stability. This method resulted in an increased acceptance rate compared to three variants of EEM, each variant sampling the parameters of the Generalised Lotka-Volterra Equation from a different statistical distribution. The acceptance rate was nearly doubled when using the abundance constraints approach for systems with a large number of species. This will unlock EEM for networks with a large number of species, leading to an ability to practically model ecosystem network structures of far greater complexity than was previously thought possible. As a demonstration of this, the abundance constraints approach is applied to a newly proposed benthic Antarctic ecosystem.

Supervised by: Dr Matthew Adams, Dr Gloria Milena Monsalve Bravo, Professor Scott Sisson and Professor Chris Drovandi ([Back](#))

## Exploring how population heterogeneity improves collective navigation performance towards a moving target

Celia Dowling\*

The University of Melbourne

**Author(s):** Celia Dowling, Stuart Johnston, Jennifer Flegg

**Time:** Wed 09:40

**Place:** Room 6

Cooperative dynamics that emerge when animals travel in groups have been shown to improve the average individual's navigational performance within a group; the ability to inform one's choice of direction by synthesising navigational cues and perception of neighbouring individuals increases the useful information available to each individual. Therefore it is no wonder that we observe numerous species migrate in groups. Humpback whales, for example, make their yearly migrations across tens of thousands of kilometers of pelagic ocean in pods of 2 to 3 individuals, using whalesong to remain in auditory contact with conspecifics over 100km away. We wish to explore the impact that population heterogeneity has on collective navigation, given that we commonly see such migratory groups in the real world containing a variety of navigational skills and authority. Thus, in this talk I will step through our constructed velocity-jump agent-based model for collective navigation in which the migrating population is heterogeneous in navigation skill, status, and speed. We also allow the sought-after target to vary spatially over time, in the constant pursuit of tractable mathematical models that faithfully capture real world dynamics.

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## Prime Amino Acids - Number Theory Meets Protein Evolution

Kevin Downard  
UNSW Sydney

**Author(s):** Kevin Downard

**Time:** Mon 16:40

**Place:** Room 1 and 2

Prime numbers have been referred to as the building blocks of natural numbers, akin to the atoms of molecules. Primes are no longer the exclusive focus of number theorists. Attention has now been placed on their prevalence in the natural world, where the application of prime numbers has found real world significance.

Common amino acid and protein classifiers such as hydrophobicity and polarity are imperfect and vary according to different scales. Molecular size and particularly mass are, in contrast, rigid classifiers that also impact on a protein's structure. Amino acid residue masses are used extensively in mass spectrometry for protein identification and sequencing.

Prime mass amino acids residues have been found to occur within proteins more often than by chance. These nine residues are predominantly hydrophobic in character and thus play an important role in protein stability and folding. Further, it has demonstrated that proteins rich in prime mass residues play an important role in biological events important to the organisation and function of the cell in the early stages of life. LUCA's proteins have been found to be enriched in these prime amino acids.

Single point mutations within prime-rich proteins can be classified as either introducing (I) retaining (R), losing (L) a prime residue, or having none (N). We have investigated whether these are more or less common across a large number of mutations (almost 16000) within a protein mutation database. We have also examined their prevalence and role in the evolution of a prime-rich protein, a transmembrane protein widely expressed across many animal species.

This abstract connects number theory, molecular mass, mass spectrometry, protein biology and evolution. ([Back](#))

## Developing on-farm management strategies for reducing H5N1 transmission in dairy cattle

Oliver Eales  
The University of Melbourne

**Author(s):** Oliver Eales, James M McCaw, Freya M Shearer

**Time:** Mon 16:00

**Place:** Room 5

Following the first introduction of H5N1 clade 2.3.4.4b from wild birds into dairy cattle in the United States (US) in early-2024, outbreaks have been ongoing with significant consequences for animal health and the US dairy industry. There is now evidence of multiple introductions of the virus into US dairy cattle from wild birds. This suggests that even if current outbreaks are controlled, introductions are likely to occur into the future, triggering new outbreaks. The dominant route of on-farm transmission of H5N1 among dairy cattle is thought to be via direct contact with milking equipment contaminated with infectious virus from an infected animal's milk. The resulting transmission dynamics due to this mode of infection have not been studied. Understanding these novel dynamics is required to identify opportunities for optimal on-farm intervention and testing strategies that can minimise the risk of and contain any future H5N1 incursions. We have developed a mathematical model of the on-farm transmission dynamics of H5N1 influenza in dairy cattle. We analyse the mathematical model and perform simulations to suggest and evaluate the effectiveness of potential management strategies. ([Back](#))

## Optimizing Two Consecutive Shutdown Maintenance Scheduling with Endogenous Uncertainty

Chathurika Srimali Gunasekara Ekanayaka Mudiyanseleage\*  
Curtin University

**Author(s):** Srimali Gunasekara, Elham Mardaneh, Sarang Kulkarni

**Time:** Wed 11:40

**Place:** Room 3

This talk presents the problem of scheduling maintenance activities across two consecutive plant shutdowns, as commonly encountered in industries such as mining, where maintenance outside scheduled shutdowns is highly undesirable. Budget, time, and resource constraints may necessitate postponing certain tasks, increasing failure risks and corrective costs. The problem is formulated as a two-stage stochastic program with decision-dependent (endogenous) uncertainty, where first-stage decisions determine postponed components and second-stage decisions adapt to realized failures. To handle the model's nonlinearity and exponential scenario growth, we decouple the two stages and propose a heuristic combining greedy search, feasibility screening, and elimination of non-promising solutions. The Sample Average Approximation (SAA) method is used to estimate expected second-stage costs efficiently. Computational experiments on randomly generated instances show that the heuristic identifies high-quality solutions with reasonable computation times, though further work is needed to accelerate scheduling for larger instances. ([Back](#))

## From whales to mosquitoes: delayed recruitment models with density dependence and competition

Maud El-Hachem  
CSIRO

**Author(s):** Maud El-Hachem, Geoffrey R. Hosack, Nick J. Beeton

**Time:** Mon 17:00

**Place:** Room 1 and 2

Age-classified models, such as Leslie matrices, are used in whale management to predict population growth and age structure over time. The linear Leslie matrix simplifies the stability analysis but can only represent the dynamics of population sizes far below carrying capacity. Incorporating nonlinear density dependence in fertility and survival rates is appropriate to represent populations near carrying capacity but adds a layer of difficulty to the analysis. Delayed recruitment is also common. Fisher and Goh (1984) collapsed the system of nonlinear difference equations into a scalar delayed difference equation to represent populations of baleen whales and studied different forms of density dependent fertility. Firstly, we explain why we are interested in the delayed Beverton-Holt formulation for density dependence of recovering baleen whale populations. Secondly, we present how we modified the delayed recruitment model to include competing species. We applied a theorem from Brualdi to study the local stability of the coexistence equilibrium for three competing species of malaria-carrying mosquitoes in Africa. The existence of a stable coexistence equilibrium was an important feature used in a spatially explicit dynamic model of mosquito population abundance. ([Back](#))

## A Variational Formulation for Plane-Strain Elasticity with Topological Defects

Edoardo Fabbrini  
Kyoto University

**Author(s):** Edoardo Fabbrini, Pierluigi Cesana, Marco Morandotti, Andrés A. León Baldelli.

**Time:** Thu 10:00

**Place:** Room 3

In this talk, I present a variational characterization of mechanical equilibrium in the plane-strain regime for elastic bodies with topological defects, such as dislocations and disclinations. By introducing a suitable core–radius regularization of the underlying singular problem and working on non–simply connected domains, I show that the equilibrium equations can be reformulated as a well-posed minimization problem for the Airy stress potential, where the relevant (in)compatibility conditions arises from the minimality condition. I then show that this problem can be reduced to a finite-dimensional optimization involving cell formulas that, perhaps surprisingly, depend only on the geometry and topology of the domain, and not on the elastic moduli or on the specific defect type. This yields an efficient computational strategy: once the domain geometry and topology are fixed, the strain and stress fields for arbitrary defects type and crystalline materials can be evaluated systematically. I conclude with numerical simulations of interacting edge dislocations and wedge disclinations, computed via a nonconforming finite element method for the associated fourth-order elliptic boundary-value problems. ([Back](#))

## Modelling interclonal cooperation in epithelial carcinogenesis using spatial models

Muhammad Asim Farooq\*  
The University of Sydney

**Author(s):** Muhammad Asim Farooq, Peter Kim, Dominic Germano

**Time:** Wed 12:40

**Place:** Room 6

This study uses vertex- and Voronoi-based computational models based on CHASTE[1] to investigate interclonal cooperation within cell populations. We analyze interactions between mutated cell types with distinct hyperproliferative and invasive properties. Modeling the cooperative dynamics among these clones shows how cellular heterogeneity affects tissue growth and invasion, enhancing the understanding of tumor progression and therapeutic target predictions.

[1] Cooper et al. 2020. Chaste: Cancer, Heart and Soft Tissue Environment. J Open Source Softw 5:1848. doi:10.21105/joss.01848 ([Back](#))

## DC optimization method for solving reverse convex programming

Kaniz Fatema\*  
RMIT University

**Author(s):** Kaniz Fatema, Sona Taheri, Adil. M. Bagirov, Andrew Eberhard

**Time:** Tue 12:40

**Place:** Room 3

We consider reverse convex programming (RCP) problems and develop a method based on the difference of convex (DC) representations of constraint functions combined with sharp augmented Lagrangians to solve them. First, the sharp Lagrangians are applied to formulate the dual problem. A method based on the  $\varepsilon$ -subdifferentials of DC components is developed to approximate the global minimizers of the Lagrangians with respect to the primal variables. A subgradient of the dual function is computed, which provides the ascent direction of this function. A new method is the combination of the  $\varepsilon$ -subdifferential for approximating global minimizers with respect to primal variables and the subgradient method for solving the dual problem. In addition, we apply a local method to refine the final solution. The proposed method is evaluated using academic test problems and compared with other methods. One application of this method is also considered. ([Back](#))

## Tendon adaptation through damage and repair mechanisms

Brendan Florio  
Murdoch University

**Author(s):** B. J. Florio

**Time:** Mon 16:00

**Place:** Room 1 and 2

Biological tendons are often erroneously thought of as static tissue. Tendons do, however, have the ability to heal and adapt to different exercise conditions, albeit very slowly. A possible mechanism for tendon adaptation is considering a homeostatic balance between fibre damage and repair. Tendons are comprised of individual fibres of different lengths, whereby short fibres are more likely to be mechanically damaged by high stresses and repair longer. On the other hand, long fibres under low stresses are more likely to be damaged by proteolytic processes and repair shorter. In this talk, we will explore tendon adaptation using a population balance model showing a dynamic response of tendon fibre length distributions to external inputs like exercise regimes. Remember to do your daily stretches! ([Back](#))

## Reliable model selection of ODE models in face of parameter non-identifiability

Elijah Foo \*

The University of Melbourne

**Author(s):** Elijah Foo

**Time:** Mon 12:20

**Place:** Room 1 and 2

In dynamical systems arising from biology and ecology, one often does not have perfect knowledge about the mathematical description of the underlying dynamics. Model selection is a statistical framework for testing competing hypotheses about these dynamics, but performing exact model selection is computationally demanding. For this reason, deterministic approximations, such as the Bayesian information criterion and the Laplace approximation, are widely used when performing model selection of ordinary differential equation (ODE) models. However, these approximations fail if some model parameters are poorly identified due to data limitations. In this talk, I will demonstrate how importance sampling-based methods are more reliable than deterministic approximations in face of parameter non-identifiability, and discuss novel extensions to these methods that improve their computational efficiency. ([Back](#))

## The Fluid Mechanics of your Morning Coffee

Larry Forbes

University of Tasmania

**Author(s):** Larry K. Forbes and Stephen J. Walters

**Time:** Tue 10:40

**Place:** Room 5

The speed of sound in air is about 370 m/s, and in pure water it is an order of magnitude greater than that. So it would be reasonable to suppose that, in a frothy fluid consisting of air and water mixed, the speed of sound ought to be some value between these two extremes, perhaps of the order of 1000 m/s. However, that is not at all what happens. Instead, the sound speed in a frothy fluid drops remarkably, to only about 20 m/s, and this is audible when using the frother to make your morning cappuccino.

This is a radically unexpected result, but is well documented experimentally. In this talk, we'll discuss a reasonably simple mathematical model that explains this peculiar phenomenon. It turns out that there is a beautiful analogy with classical gas dynamics, even to the point that shock waves can propagate through frothy fluids, at a surprisingly slow shock speed. ([Back](#))

## Chemokine Combinations in Macrophage Chemotaxis

Joshua Forrest  
The University of Melbourne

**Author(s):** Joshua Forrest, Robyn Araujo

**Time:** Wed 10:40

**Place:** Room 6

Macrophages play an important role in the body's innate immune system. They digest smaller external threats, promote healing of internal wounds, and recruit other macrophages using chemokines (chemical signals).

These chemokines bind to specialised receptors on the cell membrane. In some cases, several different chemokines may activate the same receptor yet trigger different downstream signals. The receptor CXCR3 in macrophages, for example, is activated by the chemokines CXCL9 and CXCL11. Despite activating different internal pathways, both signals can trigger chemotaxis in the macrophage.

It is not fully clear how these chemokine signals interact with each other. Will a macrophage migrate towards any of these chemokines in isolation, or is a combination required? How efficiently does a macrophage follow each signal? How does a macrophage respond to competing or conflicting chemotaxis signals? Does the function of the macrophage (its polarization state) affect this behaviour?

To answer these questions, we developed a computational model of macrophage chemotaxis that combines the internal signalling network cascades with a model of spatially diffused chemokines. We use this model to compare chemotaxis performance under different chemokine concentrations, combinations, and release schedules. In particular, we measure the relative strength and efficiency of each signal, and the persistence of chemotactic movement in the presence of conflicting signals.

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## Optimising climate sensitivity: an El-Nino Southern Oscillation case study

Gary Froyland  
UNSW Sydney

**Author(s):** Gary Froyland, Dimitrios Giannakis, Nicholas Peters

**Time:** Thu 10:40

**Place:** Room 5

The transfer operator is the natural evolution operator for functions of the underlying state variables in a dynamical system. Its spectrum and eigenfunctions carry important dynamic information, and the operator can be adjusted to perform a variety of tasks. I will introduce the notion of optimal linear response, whereby the perturbations that a system is most sensitive to are identified. This will be illustrated with sea-surface temperature perturbations that are optimised to maximally influence the strength and the speed of the El-Nino Southern Oscillation cycle. [\(Back\)](#)

## Controlling between-group payoff differences with zero-determinant strategies

Ryo Fujie  
Kyushu University

**Author(s):** Ryo Fujie

**Time:** Wed 12:20

**Place:** Room 3

Zero-determinant (ZD) strategies can enforce linear constraints on long-run payoffs in repeated games. This work studies a group-level objective in multiplayer settings: fixing the long-run difference between the average payoffs of two groups, regardless of how the other players behave. We consider finite-action multiplayer repeated games under memory-one strategies and derive feasibility conditions for between-group equalizer control, which requires that the controller can shift the group-payoff gap more than others can vary it.

We apply the framework to linear public goods games. With symmetric return rates, robust control of the between-group average payoff gap is impossible under binary actions. Introducing cost heterogeneity alone does not resolve this impossibility. In contrast, when return rates differ between groups, between-group control becomes feasible in a limited but non-empty parameter region. We characterize how feasibility depends on group sizes and the magnitude of return-rate asymmetry. ([Back](#))

## Evolution of complex singularities for Burgers' equation with discontinuous initial conditions

Jacob Gentner\*  
Queensland University of Technology

**Author(s):** Jacob Gentner, Scott McCue, Michael Dallaston

**Time:** Mon 11:20

**Place:** Room 5

Understanding how singularities emerge and evolve in partial differential equations (pdes) is essential as they can strongly influence the behavior of the solution on the real line. Burgers' equation has been used as it has an exact solution, which is not a property shared by many other nonlinear pdes. Using Heaviside initial conditions, we investigated how the singularities emerge and evolve in the complex plane, and how these results differ from a smooth initial condition. Results show that small-time asymptotics do a remarkable job at reproducing phase portraits of the exact solution up to a "smile-shaped" curve and can accurately locate the poles of the solution at small times. We also investigated how the solutions can evolve to the same structure of the traveling wave and similarity solution in the complex plane. ([Back](#))

## Quantifying land use change in low country Waitaha-region braidplains

Liam Gibson \*

University of Canterbury

**Author(s):** Liam Gibson, Jack Rose, Lauren Janssen, Sophie Horton, Ann Brower

**Time:** Tue 12:40

**Place:** Room 4

The Waitaha-Canterbury region of Te Waipounamu (New Zealand's South Island) is known internationally for its extensive system of braided rivers. A braided river is an interwoven, multi-channel network of highly mobile streams, spanning a wide, gravel riverbed. A river's braidplain is anywhere it has occupied historically – this can be kilometres wide in the unconstrained low country. We assessed change from undeveloped land to other land uses within low country near Waitaha's braided rivers and their braidplains. We used a two-phase automated and supervised remote sensing analysis to detect change in extent of developed land and exotic afforestation from previously undeveloped land covers. We find evidence of large-scale agricultural encroachment into many braidplains, posing serious flood risks for farmers and major biodiversity concerns for braided rivers and local ecosystems. ([Back](#))

## Impact of Liquidity Risk in Portfolio Selection: A New Approach

Dhruv Goel \*

University of Wollongong

**Author(s):** Dhruv Goel and Song-Ping Zhu

**Time:** Wed 10:00

**Place:** Room 3

In the literature on optimal portfolio selection, closed-form solutions are rare, especially when the additional liquidity risk is taken into consideration. In this talk, a new closed-form solution for a revised Merton (1969) model, subject to a particular form of market illiquidity, is presented. Our success hinges on innovatively interpreting the so-called “wealth turnover” adopted by Guasoni & Weber (2017) under the framework of the Leland transaction cost model (1985). As a result, we have managed to preserve the tractability so that an exact closed-form solution can be found, which enables us to provide a better discussion on the impact of liquidity risk in portfolio optimization without making an assumption on the order of the liquidity parameter, at least mathematically. As a solution verification process, we have compared our results with those of Merton (1969) and Guasoni & Weber (2017), respectively. ([Back](#))

## Timber in Trouble: Predicting Failure in Engineered Wood Products

Patrick Grant

The University of Melbourne

**Author(s):** Patrick Grant, Steven Psaltis, Maryam Shirmohammadi, Ian Turner

**Time:** Thu 09:40

**Place:** Room 3

Wood and sawn timber have been used in construction for millennia, but traditional building sizes were limited by the dimensions of the sawn boards. Modern glue-lamination techniques have revolutionised the building and construction industry, enabling the creation of large-scale engineered wood products (EWPs) that far exceed the size of the original timber. In this research, we focus on cross laminated timber (CLT) EWPs, which are significantly lighter and offer comparable strength to weight characteristics to their steel and concrete counterparts. CLT panels are composed of layers of timber boards with alternating longitudinal grain direction, and each layer is separated by a glue line. In this research, we focus on cross laminated timber (CLT) EWPs. Timber swells as it takes on moisture, which can cause internal stresses within the timber. In an EWP, moisture migration can induce stresses along the glue line, particularly if one board is wet and swelling while the other board remains dry. This shear stress can result in delamination of the glue line, which is classified as a severe structural failure.

To model these highly nonlinear moisture ingress and swelling process, we first generate a virtual representation of the EWP and then employ a two-equation variant of the well-established *TransPore* model to simulate the moisture migration and heat transfer within the EWP. The glue line in the EWP is treated as an imperfect contact boundary condition with an experimentally calibrated interfacial transfer coefficient. Lastly, the moisture fields are passed to the ABAQUS FEA software to compute the swelling stresses and strains in a post-processing procedure where experimental data is used to calibrate the moisture dependent swelling coefficients. Moreover, the flexibility in the model allows for varying climate conditions to be accounted for, ranging from the hot and humid conditions in Far North Queensland to the dry and semi-arid conditions in the Western Downs region. ([Back](#))

## Predicting Buckling in Epithelial Monolayers

Patrick Grant

The University of Melbourne

**Author(s):** Patrick Grant, James Osborne, Stuart Johnston, Ryan Murphy, Matt Faria

**Time:** Mon 12:40

**Place:** Room 1 and 2

In this research we are investigating the mechanisms that cause buckling in epithelial monolayers. We are starting with a two-dimensional, quadrilateral, vertex model based on the work of (Brown et al, 2025), where there are growth forces acting on each vertex. The movement of the vertices is determined by the minimisation of the cell energy where each cell wants to maintain a target area and perimeter, determined from the cell age. Several mechanisms are introduced to allow stability with realistic levels of cell proliferation. We investigate the buckling behaviour the model and start on the derivation of a continuum limit PDE approximation. ([Back](#))

## Mathematical Modelling of Porin-Mediated Glucose Transport in *Klebsiella pneumoniae*

Catheryn Gray

University of New South Wales

**Author(s):** Catheryn W Gray and Adelle C F Coster

**Time:** Wed 11:40

**Place:** Room 1 and 2

Quantifying the influence of transport processes on cellular growth is a central problem in biomathematics, particularly when key mechanisms are not directly observable. In microbial systems, nutrient uptake is often inferred from growth measurements, creating a need for mathematical frameworks that link transport dynamics to growth data under controlled conditions. In the current work, glucose uptake in *Klebsiella pneumoniae* porin knockout mutants is examined as a model system for outer-membrane-limited transport. Sensitivity analysis of a reduced ordinary differential equation model of glucose uptake revealed that diffusion across the outer membrane is a critical determinant of nutrient availability, motivating experimental interrogation of porin-mediated transport.

Experimental growth data from wild-type and porin-deficient *Klebsiella pneumoniae* strains are characterised across a range of glucose concentrations. The model serves as an interpretive tool to analyse how growth curves reflect underlying changes in effective outer membrane permeability and to identify conditions under which glucose transport becomes rate-limiting for growth.

Analysis of the time dependence of goodness-of-fit measures reveals an optimal experimental time window in which growth measurements are maximally informative about porin-mediated transport. This underscores the importance of temporal structure in experimental design when using phenotypic data to infer transport parameters.

Potential explanations of counter-intuitive growth behaviour in porin-deficient mutants are discussed, including adaptive responses and resource allocation trade-offs. Overall, this work illustrates how mathematical modelling can guide experimental interpretation and design in diffusion-limited biological systems, providing a general framework for linking transport, genotype, and growth. ([Back](#))

## EON: Entropy-optimal networks

Michael Groom

CSIRO

**Author(s):** Davide Bassetti, Lukáš Pospíšil, Michael Groom, Terence J. O’Kane, Illia Horenko

**Time:** Wed 10:40

**Place:** Room 3

We introduce entropy-optimal networks (EON), a novel mathematical framework for a non-equilibrium reformulation of Boltzmann machines based on the exact law of total probability, entropic regularisation and exact convex polytope representations. We show that it results in a highly-performant, but substantially cheaper, learning framework that avoids the need for gradient-based optimisation and comes with mathematically-justified existence and uniqueness criteria, as well as easily-computable confidence/reliability measures for both the model inputs and outputs. Comparisons to state-of-the-art AI methods in terms of performance, cost and model descriptor lengths on a broad set of synthetic and real-world problems with varying complexity reveal that the proposed methodology results in more performant and parsimonious models, with the EON model descriptor lengths being very close to the known complexity scaling bounds (i.e. the Kolmogorov complexity) of the synthetic problems. ([Back](#))

## Regime-switching stochastic models for temperature forecasting and weather derivative pricing

Hritika Gupta  
University of Wollongong

**Author(s):** Hritika Gupta, Mariano Rodrigo

**Time:** Wed 10:20

**Place:** Room 3

We introduce a regime-switching stochastic harmonic-oscillator model for daily average temperature forecasting, motivated by weather-derivative pricing. The model decomposes temperature into a deterministic seasonal component and a stochastic component whose parameters depend on a hidden Markov chain. Parameters and regime dynamics are estimated using a filter based EM algorithm, yielding accurate recovery of model and Markov chain parameters with efficient computation in simulation experiments. Applied to daily temperature series from Canada and Australia, the model substantially improves predictive accuracy over purely seasonal benchmarks and exhibits stable out-of-sample performance. We illustrate practical relevance by pricing temperature-based derivatives (for example, HDD call options) using the fitted model. ([Back](#))

## The Price of Anarchy in Strategic Queues

Ashley Hanson \*  
The University of Melbourne

**Author(s):** Ashley Hanson

**Time:** Mon 15:00

**Place:** Room 6

In this talk we consider a system of multiple interacting facilities in a general service system. In each facility, customers are served by parallel servers. An arriving customer is either assigned to a facility or is rejected from entering the system. We model the interaction between facilities as a strategic-form game, where each facility chooses a customer threshold. The probability that an arriving customer is assigned to a particular facility (or is rejected) depends on both the configuration of thresholds and the occupancy of all facilities in the system. After deriving the configurations of thresholds which are Nash equilibria of the system, we use the Price of Anarchy to determine how inefficient the worst performing Nash equilibrium is compared to the socially optimal configuration of thresholds, with respect to customer throughput. ([Back](#))

## Improvement on the Worst-Case Runtime for Calculating Minimum Volume Covering Ellipsoids

Elizabeth Harris  
The University of Newcastle

**Author(s):** Elizabeth Harris

**Time:** Wed 12:20

**Place:** Room 4

The Minimum Volume Ellipsoid (MVCE) Problem seeks the ellipsoid of smallest volume containing a set of  $n$  points in  $\mathbb{R}^d$ . In this talk, we introduce the MVCE problem, as well as its dual problem, the  $D$ -optimal design problem. We then briefly introduce the Frank-Wolfe algorithm, which can be used to solve MVCEs. We then present a new theoretical result: an improved upper bound for the initial optimality gap when using Khachiyan's initialisation (which places equal weights on all points). As an immediate consequence, this improves the worst case runtime for the Frank-Wolfe algorithm. ([Back](#))

## Applications of a model of type 2 diabetes

Catherine Hassell Sweatman  
Auckland University of Technology

**Author(s):** Catherine Z. W. Hassell Sweatman

**Time:** Wed 11:20

**Place:** Room 1 and 2

The development or remission of diet-induced overweight type 2 diabetes involves many biological changes which occur over very different timescales. Remission, defined by  $\text{HbA}_{1c} > 6.5\%$ , or fasting plasma glucose concentration less than 126 mg/dl, may be achieved rapidly by following weight loss guidelines. However, remission is often short-term, followed by relapse to higher glucose levels. Mathematical modelling provides a way of investigating a typical situation, in which patients are advised to lose weight and then maintain fat mass. Modelling predicts that a trajectory which maintains weight will be a relapse trajectory, if the fat mass chosen is too high, the threshold being dependent on the lipid to carbohydrate ratio of the diet. Modelling takes into account the effects of hepatic and pancreatic lipid on hepatic insulin sensitivity and  $\beta$ -cell function, respectively. This study leads to the suggestion that type 2 diabetes remission guidelines be given in terms of model parameters, not variables; that is, the patient should adhere to a given nutrition and exercise plan, rather than achieve a certain subset of variable values. The model predicts that calorie restriction, not weight loss, initiates remission from type 2 diabetes; and that advice of the form ‘adhere to the diet and exercise plan’ rather than ‘achieve a certain weight loss’ may help counter relapse. The model may also be applied to understanding different metabolic phenotypes. ([Back](#))

## Mathematical Modeling and Numerical Simulation of Localized Bioconvection

Yoshimichi Hayashi\*  
Kyushu University

**Author(s):** Yoshimichi Hayashi, Atsushi Tero

**Time:** Mon 17:00

**Place:** Room 4

Various mathematical models of bioconvection have been proposed in previous studies, most of which are based on fluid dynamics. However, recent reviews suggest that a hybrid model integrating Turing mechanisms with fluid dynamics is a promising direction for future research. In this study, we propose a simplified mathematical model of bioconvection using a reaction-diffusion framework without relying on fluid dynamics, serving as an initial step toward such hybrid models.

We focused on the microorganism \*Euglena gracilis\*, which exhibits negative phototaxis and has a specific gravity greater than water. Experimental observations confirmed that \*Euglena\* accumulate at the surface under light, leading to instability and localized convection patterns. To simulate this, we developed a two-layer model incorporating a “localizer” variable to reproduce the central localization observed in experiments. Numerical simulations of this model successfully demonstrated localized bioconvection patterns in 1 & 2 dimensions, suggesting that the essential features of bioconvection can be captured by a simplified reaction-diffusion system. ([Back](#))

## Duality for frames - and application to MRA wavelet construction

Andreas Heinecke  
The University of Newcastle

**Author(s):** Andreas Heinecke

**Time:** Wed 12:40

**Place:** Room 5

Hilbert space frames are advancements of orthonormal bases - allowing built-in redundancy and sparse signal representation. The duality principle is a universal principle in frame theory. Its essence is the unitary equivalence of the frame operator and the Gramian of certain adjoint systems. We show how in the arena of multiresolution-analysis (MRA) wavelet frames, the unitary extension principle can be viewed as the duality principle in a sequence space. This perspective leads to a construction scheme for dual wavelet frames which is strikingly simple in the sense that it only requires the completion of an invertible constant matrix. Under minimal conditions on the MRA, this guarantees the existence and easy constructability of non-separable multivariate dual wavelet frames. ([Back](#))

## Taming Non-Manifold Meshes and Simulating Bubbles with Colours

Peter Heiss Synak  
Australian National University

**Author(s):** Peter Heiss Synak, Aleksei Kalinov, Malina Strugaru, Arian Etemadi, Huidong Yang, Chris Wojtan, Sadashige Ishida

**Time:** Mon 17:00

**Place:** Room 6

In simulations, representing soft matter using surface meshes offers exceptional level of surface detail. Unfortunately, mesh geometries can easily enter faulty states, such as colliding, inverting, self-overlapping and more, making it necessary to occasionally correct mesh topology in order to maintain physical plausibility. I will illustrate these issues for the case of simulating soap bubbles. Then, I will present a surface-tracking algorithm we developed to tackle these problems in a non-manifold setting. Our algorithm combines surface detail preservation, characteristic of mesh-based methods, while reliably handling diverse topological changes, similar to level set methods. I will also touch on the aspects that make our algorithm numerically robust. ([Back](#))

## New Method for Analyzing The Hole-Structure of a Crystal: Merge Trees of Periodic Filtrations

Teresa Heiss-Synak  
The Australian National University

**Author(s):** Herbert Edelsbrunner, Teresa Heiss

**Time:** Mon 11:40

**Place:** Room 4

Periodic data is abundant in materials science; for example, the atoms of a crystalline material repeat periodically. Additionally, periodic boundary conditions are used in many simulations, for example in molecular dynamics simulations of materials, to remove boundary effects. However, it is unclear how to deal with the periodicity of the data when computing topological descriptors, like the merge tree or persistent homology, which track connected components or holes at different length scales. A classical approach is to compute the respective descriptor simply on the torus. However, this does not give the information needed for many applications and is even unstable under certain types of noise. Therefore, we suggest decorating the merge tree gained from the torus with additional information, describing for each connected component on the torus how many components of the infinite periodic space map to it. As there are often infinitely many, we describe their density and growth rate inside a growing sphere. The resulting periodic merge tree and its induced periodic 0-th persistence barcode carry the desired information and satisfy the desired properties, in particular: stability and efficient computability (under mild assumptions, the running time is of order  $(n + m)\log(n)$ , where  $n$  and  $m$  are the number of vertices and edges per fundamental domain). This is joint work with Herbert Edelsbrunner. ([Back](#))

## Estimation of *Aedes albopictus* abundance based on a dengue outbreak in Australia

Roslyn Hickson  
CSIRO and James Cook University

**Author(s):** Francisca Powell-Romero, Matthew Ryan, Justin Sexton, Kamran Najeebullah, Nick Beeton, Brendan Trewin, Roslyn Hickson

**Time:** Thu 09:40

**Place:** Room 6

Following its discovery in 2005, the Asian tiger mosquito, *Aedes albopictus* has posed a significant disease threat in the Australian Torres Strait Islands. In particular, multiple dengue outbreaks have been recorded across the region within the last decade, the most recent of which occurred in 2024 on the eastern island of Mer (Murray Island). Modelling the potential impact of next-generation control strategies – such as *Wolbachia* and genetically engineered approaches – is fundamental to reducing the risk of future outbreaks. However, these models typically rely upon abundance data to estimate mosquito population size, which can be difficult to obtain due to the resource-intensive nature of the collection process. In the absence of abundance data, we estimate the mosquito population size by applying a dengue transmission model based on the 2024 outbreak on Mer. ([Back](#))

## Optimal profiles in confined and non-Newtonian flows

Edward Hinton  
The University of Melbourne

**Author(s):** Edward Hinton and Mohit Dalwadi

**Time:** Tue 10:20

**Place:** Room 5

Drag-minimising shapes in creeping flows are of fundamental fluid dynamical interest and have important applications in micro-swimming, micro-fluidics, biofilm formation and drug delivery. In many of these settings, the flow is confined within a finite domain or the fluid has non-Newtonian properties. In this talk, we show how the optimal shape is adjusted from the classical case of unbounded Stokes flow to account for these different contexts. For example, the surface vorticity on the optimal body in a Herschel-Bulkley fluid is constant over the entire body. This result enables a local analysis of the flow at the tips of the body, which also determines the optimal tip angle. ([Back](#))

## Mathematical modelling of endemic SARS-CoV-2 transmission and implications for vaccination strategies

Alexandra Hogan  
UNSW Sydney

**Author(s):** Alexandra Hogan, David Muscatello, Bette Liu, Gemma Nedjati-Gilani, James Wood

**Time:** Thu 10:40

**Place:** Room 6

In an era of endemic SARS-CoV-2 transmission, countries are evaluating schedules for ongoing COVID-19 booster vaccinations. Mathematical modelling provides a useful tool to predict the benefit of future vaccination strategies, incorporating the loss of protection due to waning immunity and strain mutation.

We adapted a combined immunological-population transmission model for SARS-CoV-2, to better capture contemporary understanding of exposure- and vaccine-derived immunity. We used this model to estimate the impact of targeted booster dose strategies in the older population, both in the context of continued circulation of the current dominant viral strain, and in the presence of a new antigenically distinct variant.

We found that at the population level, an annual COVID-19 vaccine booster dose to the 65+ years population at 60% coverage could avert 8–16% of hospitalisations over a single wave, depending on how well-matched the vaccine is to the circulating SARS-CoV-2 strain. A second booster dose to the 75+ population after 6 months was particularly beneficial if a new distinct variant strain emerges. Of the scenarios explored, we found that increasing uptake of the annual booster dose in the 65+ population is likely to have a larger impact on hospitalisations than optimising dose timing. ([Back](#))

## Optimising Restoration Portfolios Through Spatial Heterogeneity and Climate Risk

Jordan Holdorf\*  
Griffith University

**Author(s):** Jordan Holdorf, Melanie Roberts, Ivan Diaz-Rainey, Christopher Brown

**Time:** Wed 10:20

**Place:** Room 4

Nature markets are reshaping the financing of restoration and conservation projects by linking ecological outcomes - such as carbon sequestration - to financial returns. This presents both new opportunities and challenges for investment planning, requiring strategies that integrate ecological benefits with financial viability. To optimise outcomes in this dual context, decision frameworks must account for both temporal dynamics and spatial heterogeneity. Building on our previous work with a temporal optimisation model, we extend the framework to a spatio-temporal setting, emphasising the ecological, climatic and financial variability across space. The model incorporates site-specific factors, including restoration costs, carbon sequestration rates, and exposure to stochastic climate events. Investment decisions are evaluated over a 25-year horizon through a value iteration model, with optimal strategies derived using stochastic dynamic programming.

In this presentation, we examine how spatial configuration influences not only the outcomes of restoration projects - measured by cumulative carbon sequestration, net present value, and profitability index - but also the structure of the investment strategies themselves. We compare how different spatial arrangements and risk profiles lead to changes in the timing, scale, and location of investments. Results show that accounting for spatial heterogeneity and climate uncertainty can shift restoration priorities, alter adaptive strategies over time, and ultimately influence projects' financial and environmental viability, underscoring the importance of integrated, dynamic modelling approaches in nature market decision-making. ([Back](#))

## Evolutionary game theory for better environmental decisions

Kailas Honasoge\*  
Delft University of Technology

**Author(s):** Kailas Honasoge, Joel Brown, Katerina Stankova, Mathew Adams, Maria Kleshnina

**Time:** Mon 16:20

**Place:** Room 1 and 2

While human activities drive rapid evolution, many conservation and management policies treat species as if they were evolutionarily static. This often results in failed interventions, such as the emergence of pesticide resistance or the uncontrolled spread of invasive species, where evolution outpaces policy. To address this, we propose a mathematical framework utilizing Stackelberg Evolutionary Games (SEGs) to formalize the strategic interplay between environmental managers and adapting biological systems. In this leader-follower hierarchy, the manager acts as the leader by implementing policies, while species act as followers that respond through eco-evolutionary dynamics. We use the G-function formalism to link population and trait dynamics. We demonstrate the utility of the SEG framework by illustrating how the interaction between management goals and species' evolutionary responses can be analyzed. Preliminary results indicate that ignoring evolutionary responses can lead to reduced phenotypic variance, and loss of adaptive potential. With this framework, by anticipating adaptive responses, managers can steer evolutionary trajectories towards or away from particular states. ([Back](#))

## How Does Short-Term Broad Immunity Influence Antigenic Evolutionary Dynamics in Influenza?

Yilei Huang\*

The University of Melbourne

**Author(s):** Yilei Huang, James M. McCaw, Oliver Eales\*, Freya M. Shearer\*

**Time:** Wed 10:00

**Place:** Room 5

Seasonal influenza remains a persistent public health concern worldwide. Its long-term circulation is characterised by antigenic drift—the gradual accumulation of mutations in viral surface proteins that enables new variants to evade existing population immunity. These continual antigenic changes enable the replacement of previously circulating strains by antigenically novel variants. The rapid mutation of influenza virus and the dynamic changes in population-level immunity contribute to its complex transmission pattern, yet the interplay between different immune protective effects and mutation processes still lacks systematic analysis. Building on a continuous trait-space mathematical model of Sasaki et al., this study develops a one-dimensional multi-strain transmission model that integrates long-term cross-immunity decaying with antigenic distance, short-lived and broadly protective immunity following infection, and viral mutation represented as a diffusion process. Numerical simulations are used to track transmission and evolutionary dynamics over multi-year time scales. We use metrics such as wavefront speed and inter-epidemic period to examine how immune structure and mutation rate influence antigenic drift speed, epidemic periodicity, and long-term background infection prevalence. Our model allows us to systematically investigate how the width of long-term strain-specific protection, the duration of short-term broad immunity, and the rate of viral mutation interact to shape the long-term epidemiological and evolutionary dynamics of influenza. We found that the persistence of short-term broad protection slows antigenic drift, which has implications for the development of so-called universal influenza vaccines. ([Back](#))

## A robust machine learning model of classification and feature selection

Yingkun (Queenie) Huang\*

University of New South Wales

**Author(s):** Q. Y. Huang, N. D. Dizon, N. Jeyakumar, V. Jeyakumar

**Time:** Wed 12:20

**Place:** Room 3

In this talk, we introduce an efficient machine learning method based on robust Support Vector Machines (SVMs) that simultaneously classifies data and selects relevant features whilst accounting for data uncertainty. Based on Wasserstein distributionally robust optimization, we develop computationally feasible robust SVM models along with efficient second-order cone programming methods using an integrated application of tools from convex non-smooth analysis and difference of convex optimization. Our computational results on benchmark datasets demonstrate that these robust SVMs identify relevant features whilst achieving higher classification accuracies than the conventional (non-robust) SVM models, especially for datasets with more features than instances. Applying our method to a novel dataset of handwriting samples from individuals with Alzheimer's disease and a control group, the model was able to distinguish between both groups with greater than 80% accuracy and using only 37% (168/450) of all available features, outperforming previous SVM models and providing insights into the unique characteristics of the disease. ([Back](#))

## Evaluating *Plasmodium vivax* treatment policies: an economic perspective

Elizabeth Ivory\*

The University of Melbourne

**Author(s):** Elizabeth Ivory

**Time:** Tue 09:40

**Place:** Room 1 and 2

*Plasmodium vivax* is the most geographically widespread malaria-causing parasite. It can produce latent, liver-stage parasites (hypnozoites) which may cause multiple malaria relapses from a single new infection. In order to kill these hypnozoites and prevent *Plasmodium vivax* relapses, a liver-stage treatment such as primaquine or tafenoquine is required. When paired with a blood-stage treatment to treat the active infection, it is termed “radical cure”. However, those with a deficiency of the glucose-6-phosphate dehydrogenase (G6PD) enzyme (up to 30% of a population) are at high risk of adverse reactions to radical cure treatment, such as haemolysis.

In this talk we compare expanded *Plasmodium vivax* treatment policies with a baseline treatment policy, to investigate the difference in total costs and quality-adjusted life years following the change. We use this to evaluate the cost-effectiveness of proposed wider radical cure prescription following G6PD testing for malaria patients. ([Back](#))

## Mathematical Modelling of Retinal Immune Cells During Inflammation

Tristen Jackson\*

QUT

**Author(s):** Tristen Jackson, Adrienne Jenner, Samantha Dando

**Time:** Mon 10:40

**Place:** Room 1 and 2

Inflammation alters both the behaviour and spatial distribution of retinal microglia, the primary immune cells of the eye. In experimental studies, mice were administered an inflammation-inducing compound (LPS), and microglial cell densities were quantified over 48 hours in each layer of the retina. Remarkably, microglia density was conserved, while significant redistribution occurred between layers.

To explain this phenomenon, we developed an ODE model describing inter-layer retinal microglia migration during inflammation. A pharmacokinetic (PK) subsystem was first parameterised to capture the dynamics of our inflammation-inducing compound (LPS). This PK model was then coupled to an immune cell subsystem, where movement between retinal layers is driven by the concentration of LPS.

This mathematical model represents the first to describe ocular inflammation and is one of very few computational models of the neuroimmune system. Reparameterisation has enabled predictions of retinal microglia redistribution across different LPS dosages, host species, and routes of administration, making our model robust to differences in experimental design. Furthermore, classical analyses such as sensitivity analysis and parameter exploration will be discussed. ([Back](#))

## Computation of Three Dimensional Free Surface Flow Inverse Problems Using Boundary Integrals

Elizabeth Jagerma \*  
Adelaide University

**Author(s):** Elizabeth Jagersma

**Time:** Wed 11:40

**Place:** Room 5

Free surface flow problems involve determining the interface between air and water in a fluid flow. The flow may have a pressure distribution at the top, which could be caused by objects floating on the surface, and it could have a non-trivial bottom topography. With some assumptions placed on the flow, this problem is reduced to solving the Laplace equation with nonlinear boundary conditions, however the problem is complicated by the fact that the boundary is unknown. One approach is to use a boundary integral method, wherein the problem is reduced to a surface integral at the boundary. These boundary integral techniques are well understood, and have been discussed in the literature. In the forward problem, a pressure distribution at the free surface or a non-trivial bottom topography is supplied and the free surface must be solved for. My research concerns the inverse problem, where a free surface is known, but there is an unknown non-trivial bottom topography or an unknown pressure distribution at the free surface which must be determined. This talk will discuss my findings on three versions of this inverse problem, in both the finite depth and infinite depth setting. ([Back](#))

## A time-inhomogeneous Markovian model for demography of women

Thisaakhya Jayakody \*  
The University of Melbourne

**Author(s):** Sophie Hautphenne, Thisaakhya Jayakody, Peter Taylor

**Time:** Tue 12:20

**Place:** Room 1 and 2

A woman's lifetime and the progression of her descent tree can vary according to her country of origin, and both these aspects can be investigated using stochastic models. We apply matrix analytic methods and show that a time-inhomogeneous Markovian model is suitable for modelling the lifetime of a woman and the long-term behaviour of her descent tree. We use age specific fertility and mortality rates published by the United Nations to inform the model parameters. Using this model, we analyse various characteristics of a woman and the descent tree initiated by a single woman. We introduce methods to analyse these properties, present the results across various time periods and perform a cross-country comparison.

Keywords: Stochastic models, Markovian models, Demography, Descent trees ([Back](#))

## Coke reactivity with CO<sub>2</sub> and H<sub>2</sub>O and impacts on coke microstructure

David Jenkins

The University of Newcastle

**Author(s):** Ai Wang, Salman Khoshk Rish, David R Jenkins, Arash Tahmasebi

**Time:** Mon 10:00

**Place:** Room 4

As part of efforts to reduce CO<sub>2</sub> emissions from the steelmaking process, hydrogen gas can be injected into an ironmaking blast furnace to replace pulverised coal. The combusted product is steam, which can react with metallurgical coke inside the blast furnace. This work considers the relative effects of steam reactivity with coke at high temperature, in comparison to reactivity with CO<sub>2</sub>. The aim is to understand the effect of the reaction on the degradation of coke microstructure. The work uses a combination of measurement of mass loss in TGA, micro-CT imaging to evaluate the variation on coke degradation through the structure and a random pore reaction-diffusion model to evaluate the reaction rate and effective gas diffusion parameters. The results indicate that reaction with H<sub>2</sub>O is faster than with CO<sub>2</sub>, with a tendency towards more mass loss near the coke surface. The consequences for coke degradation in the blast furnace are discussed. ([Back](#))

## A signal-processing method for analysing how orchard production systems affect ground-level microclimate

Heather Jenkins  
Bioeconomy Science Institute

**Author(s):** Heather Jenkins, Maryam Alavi, Karin Müller, Joanna Sharp

**Time:** Tue 10:40

**Place:** Room 4

In perennial horticultural tree crops, apples for example, the orchard's characteristics, such as tree density, row spacing and orientation, and canopy geometry, act as a complex, nonlinear, spatially distributed filter that transforms the broad-scale, low-resolution weather signal from the open field into the orchard's microclimate. In our study, we are interested in the microclimate at ground-level, which affects plant understory community composition and function in the orchard. Dense sensor networks, used to collect microclimate data, are often limited by their operational costs at commercial scales. Modelling approaches are hence required for capturing the nonlinear transformation from the open-field weather stations to the orchards' microclimate. In this talk, we take a signal processing approach to this transformation, considering the orchard's row spacing and training system as the main contributing factors to the ground-level microclimate. We overview the challenges arising from data collection scenarios in the field, and the limitations of applying theoretical assumptions to the real-time data. We use multi-stage signal decomposition to quantify the features of the individual observed signals, then use multivariate techniques to discover the important discriminant features.

The data used in this study were obtained from a micro-environmental sensor network installed in a research orchard from the Bioeconomy Science Institute in Motueka, Aotearoa New Zealand, over a period of three years. Three sensors for each of the parameters air temperature, relative humidity, and photosynthetic active radiation were installed within the alleyways of paired blocks of tall spindle and narrow-row planar-cordon planting systems in the mature apple orchard, and three at supplementary sites in open-field areas with similar vegetation close to the experimental orchard but without the influence of surrounding trees. The conventional weather station near the orchard blocks was considered as a proxy to the low-resolution weather signal. The data were logged (HOBO RX2106 MicroRX) in resolutions from 5 to 30 min depending on the season and the parameters. We discuss practical steps in the signals' pre-processing, decomposition, and feature extraction, considering that every extracted feature must be physically relatable to the orchard's management framework. ([Back](#))

**In silico trial of a cancer treatment combining a virus and an immune "magnet"**

Adrienne Jenner

Queensland University of Technology

**Author(s):** Adrienne Jenner**Time:** Thu 10:20**Place:** Room 1 and 2

The immune system has the ability to kill cancer cells; however, cancer cells are able to resist immune cell-mediated killing. A new therapy uses modified measles viruses to activate the immune system against cancer. These viruses are modified with bi-specific T-cell engagers (BiTEs) which assist immune cells in targeting and removing cancer cells, a bit like a "magnet". While the potential success of this treatment has been demonstrated in mouse models, it is yet to be verified in a human cohort. In this work, we use mathematical and computational simulations to examine how patient-to-patient variability might affect the success of this treatment. We compare our model predictions to data from a clinical trial and find that virtual individuals in the simulation that are classified as non-responders to the standard protocol would likely respond better to more frequent administrations of lower dosages. The work presented here generates hypotheses for how individuals in a human cohort may respond. ([Back](#))

**Quantifying biological heterogeneity in nano-engineered particle–cell interaction experiments**

Stuart Johnston

The University of Melbourne

**Author(s):** Stuart Johnston, Ryan Murphy, Matthew Faria, James Osborne**Time:** Thu 10:00**Place:** Room 1 and 2

Nano-engineered particles are a promising tool for medical diagnostics, biomedical imaging and targeted drug delivery. Fundamental to the assessment of particle performance are in vitro particle–cell interaction experiments. These experiments can be summarized with key parameters that facilitate objective comparisons across various cell and particle pairs, such as the particle–cell association rate. Previous studies often focus on point estimates of such parameters and neglect heterogeneity in routine measurements. In this study, we develop an ordinary differential equation-based mechanistic mathematical model that incorporates and exploits the heterogeneity in routine measurements. Connecting this model to data using approximate Bayesian computation parameter inference and prediction tools, we reveal the significant role of heterogeneity in parameters that characterize particle–cell interactions. We then generate predictions for key quantities, such as the time evolution of the number of particles per cell. Finally, by systematically exploring how the choice of experimental time points influences estimates of key quantities, we identify optimal experimental time points that maximize the information that is gained from particle–cell interaction experiments. ([Back](#))

**Rapid Offline Training for Deep Material Networks:  
A Displacement-Based Laminate Formulation and Novel Sampling for Fatigue  
Modeling**

Matthias Kabel  
Fraunhofer ITWM

**Author(s):** Pavan Bhat Keelanje Srinivas, Matthias Kabel, Matti Schneider

**Time:** Mon 10:40

**Place:** Room 4

Deep Material Networks (DMNs) [1] have emerged as powerful surrogate models for capturing the microstructural behavior of composites in multiscale simulations. However, the initial offline training phase—where laminate parameters are identified using supervised learning on precomputed elastic data—remains a computational bottleneck, especially for industrial-scale applications. In this work [2], we introduce two key innovations to address this challenge. First, we systematically compare three formulations for evaluating the effective elastic properties of laminates within DMNs. Our findings demonstrate that a displacement-based laminate formulation accelerates the training process by a factor of seven compared to the widely used Milton equation, without compromising accuracy. Second, we propose a novel sampling strategy for stiffness tensors tailored to compliance-based fatigue-damage models. This approach ensures robust training and enhances the predictive accuracy of DMNs in fatigue simulations. The effectiveness of these advancements is validated through computational experiments on glass-fiber reinforced composites, showing substantial speed-up and reliability gains. Our results pave the way for scalable, efficient, and accurate DMN-based modeling of complex composite structures, making them highly attractive for industrial applications involving fatigue and durability assessments.

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<https://doi.org/10.1016/j.cma.2018.09.020>
2. P. Bhat Keelanje Srinivas, M. Kabel, M. Schneider, “Rapid Offline Training for Deep Material Networks via a displacement-based laminate formulation and a novel sampling technique for a compliance-based fatigue model,” *Computer Methods in Applied Mechanics and Engineering*, vol. 449, 2026.  
<https://doi.org/10.1016/j.cma.2025.118517>

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## A Markov Process-Based Mathematical Model of Vascular Stenosis Formation and Treatment

Taiga Kadowaki \*  
Kyushu University

**Author(s):** Taiga Kadowaki, Atsushi Tero

**Time:** Tue 12:40

**Place:** Room 1 and 2

Vascular stenosis progresses as lipids in the bloodstream accumulate on vessel walls, forming plaques. In this presentation, we propose a novel mathematical model based on a Stokes-flow driven Markov process to unifiedly describe both the formation of plaques and their destruction by drugs (treatment). Our model extends the conventional Diffusion-Limited Aggregation (DLA) model. Specifically, we describe the flow field within the vessel using a lubrication approximation and formulate the advection and diffusion of particles as probabilistic transitions influenced by this flow. Furthermore, by introducing a surface diffusion effect after attachment, we suppress unrealistic dendritic structures and reproduce smooth morphological changes characteristic of actual plaques. Through numerical simulations, we discuss how the sensitivity of particles to advection affects plaque growth patterns and the efficiency of drug delivery. This approach enables the analysis of vascular stenosis dynamics with low computational cost while accounting for stochastic fluctuations that are difficult to capture with continuum models. ([Back](#))

## Truss Structures with Mechanical Optimality Generated by Integrable Discrete Holomorphic Functions

Kenji Kajiwara  
Kyushu University

**Author(s):** Kenji Kajiwara, Kentaro Hayakawa, Kazuki Hayashi, Yoshiki Jimukaru, Motoki Masada, Yohei Yokosuka

**Time:** Mon 12:00

**Place:** Room 4

We consider the a class of truss structures called the "Michelle structure" which is a classical structure in architecture originated by the pioneer work of A.G.M. Michelle (1904). It is characterised by the variational principle minimising the sum of  $|(\text{axial force})| \times (\text{length of each edge})$  (the Michell functional). It is well-known that Michelle structures have the property that  $|(\text{axial force})| \times (\text{length of each edge})$  is a constant. We call such structures "Michell-Prager type structures". In this talk, we show that the Michell-Prager type structures can be generated systematically from the integrable discrete holomorphic functions. Also, their mechanical properties can be governed by the geometry of discrete isothermic surfaces[1].

For example, the discrete exponential function gives rise to a discrete version of the original Michelle's structure, and it is numerically shown that it is approximately minimise the Michell's functional[2]. Since the basic property of the discrete holomorphic function is preserved under Möbius transformation, one can transform the structure on the sphere to construct a 3D Michelle structure.

We present another example of the Michell-Prager type structures generated by the discrete power functions and the discrete log function, which arise in the lattice of the Bäcklund transformations of the Painlevé VI equation, having the explicit formula in terms of its hypergeometric  $\tau$  functions[3]. We show that the truss structures give approximate Michell structures under suitable boundary conditions which is verified by numerical optimisation with respect to the Michell functional.

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- [1] W. K. Schief, Integrable structures in discrete shell membrane theory, Proc. R. Soc. A, **470** (2014), 20130757.
- [2] K. Hayashi et al., Parametric generation of optimal structures through discrete exponential functions: unveiling connections between structural optimality and discrete isothermicity. Struct. Multidiscip. Optim., **67**(3)(2024), 41.
- [3] H. Ando et al., An explicit formula for the discrete power function associated with circle patterns of Schramm type, Funkcial. Ekvac., **57**(1)(2014), 1-41.

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## Intercellular Forces Regulate Stratification and Turnover in a Two-Layer Corneal Epithelium

Neda Khodabakhsh Joniani\*  
The University of Sydney

**Author(s):** Neda Khodabakhsh Joniani, David Martinez-Martin, Peter S. Kim, J. Guy Lyons

**Time:** Mon 10:40

**Place:** Room 6

The corneal epithelium is a self-renewing tissue maintained with remarkable precision. Its regeneration is driven by limbal epithelial stem cells (LESCs), which reside at the corneal periphery and give rise to transit amplifying cells (TACs) that migrate centripetally toward the centre. These TACs continually replenish the tissue and, together with vertical delamination between layers, sustain the five to seven stratified layers of the epithelium. Despite this well-coordinated renewal, the mechanical processes that regulate epithelial stratification remain poorly understood. In this talk, I present simulation results demonstrating that stratification is tightly coupled to TAC proliferation, whereas LESK activity remains largely unchanged, consistent with their slow-cycling behaviour. Weakening cell–substrate adhesion increases epithelial turnover without the need for external growth factor stimulation. We also find that increased surface shedding promotes both division and delamination, while excessive shedding triggers mechanical compensation in the form of cell stretching in the upper layer—providing a plausible explanation for the enlarged cells commonly observed in the superficial epithelium. The model further predicts a direct relationship between the shedding rate and the centripetal velocity of clonal expansion, reflecting a wound-healing-like acceleration of epithelial migration. Overall, these results highlight how intercellular forces coordinate cell size, migration, and turnover to maintain and rapidly restore epithelial integrity. In this talk, I also introduce an extension of the model to a five-layer epithelial structure and demonstrate the wound healing mechanism. Finally, I briefly outline our approach for constructing a corresponding PDE framework that captures these mechanical principles. ([Back](#))

## Cooperating on networks: inequality and social structure

Maria Kleshnina  
QUT

**Author(s):** Manuel Staab, Maria Kleshnina, Peter Bayer, Yann Bramoulle

**Time:** Tue 11:40

**Place:** Room 3

This paper analyses how inequality in endowments and social structure jointly affect individuals' ability to cooperate. Individuals repeatedly invest in a local public good (“cooperation”) in an environment that is described by a distribution of endowments and a network of beneficiaries. We measure the cooperativeness of an environment by the minimum discount factor needed to sustain (any) cooperation in equilibrium. We characterise the endowment distribution that maximises cooperativeness for any given network and the corresponding minimum discount factor. The latter is shown to be inversely proportional to the maximal index of the graph describing the network. The corresponding Perron eigenvalue of the adjacency matrix characterises the most cooperative income distribution. Moreover, we show that if an environment maximises cooperativeness (over all income distributions and networks of a certain size), then the network is described by a *nested split graphs*. We further show that this is the same class of graphs that maximise welfare for any given discount factor, and yet, the most cooperative graph need not be equal to the most efficient. ([Back](#))

## Periodic soil heat flow – the phase difference between maximum heat flux and maximum temperature

John H Knight  
Australian National University

**Author(s):** John H Knight

**Time:** Mon 12:40

**Place:** Room 5

The problem of soil temperature variation in response to a periodic variation of the temperature at the soil surface has been studied and solved analytically a long time ago. For each frequency a temperature wave travels down through the soil while its amplitude decays exponentially with depth, with higher frequencies being more strongly damped. The solution works well for both the daily and annual variations in surface temperature, as confirmed by field measurements. The solution gives a phase difference between the temperature wave and the corresponding soil heat flux wave of one eighth of a period, three hours for the daily wave and a month and a half for the annual wave.

Over my long career as an environmental applied mathematician I have often been asked why this is so – why is the daily peak of solar radiation at about noon, whereas the hottest daily temperature is several hours later? I have usually replied that the phase lag is what the mathematics requires.

In this talk I will give a more detailed explanation. I will derive a solution for a soil of finite depth with an insulating boundary at the base, and show how the phase lag between heat flux and temperature varies with the finite depth, reaching a limit as the depth of the soil layer approaches zero. ([Back](#))

## Quantitative methods for motion trace fossils

Lyndon Koens  
The University of Adelaide

**Author(s):** Brittany Laing, Gabriela Mangano, Luis Buatois, Glenn Brock, Lyndon Koens

**Time:** Wed 12:00

**Place:** Room 6

Trace fossils are the fossilized paths and trails of ancient organisms. They are among the oldest kinds of fossils (550 million years old), often providing trails for organisms which we know nothing else about. The study of these trails could lead to key insights into early evolution but is frequently done qualitatively. In this presentation I will discuss how bacterial behaviour studies can help us quantify and understand the behaviour of the earliest prehistoric organisms. ([Back](#))

## Weak comparisons between compact surfaces

Kazuki Koga  
Institute of Science Tokyo

**Author(s):** Kazuki Koga

**Time:** Thu 10:40

**Place:** Room 4

In this talk, we present a novel comparison algorithm based on Fourier analysis for compact surfaces embedded in the three-dimensional Euclidian space. The key idea is to identify those objects with the associated surface measures and compute a weak distance between them in terms of the inhomogeneous Sobolev norm of negative order via the Plancherel theorem. This approach allows several advantages including high accuracy due to fast-converging numerical quadrature rules, acceleration by the nonuniform fast Fourier transform, and parallelization on GPUs. As numerical experiments, we apply the suggested algorithm to quantifying discretization errors in triangulations of the unit sphere. ([Back](#))

## Modeling the effects of cross immunity and control measures on competitive dynamics of variants in the USA, UK, and Brazil

Komal Komal\*  
Swinburne University of Technology

**Author(s):** Komal Basaiti, Anil K. Vashishth, Tonghua Zhang

**Time:** Tue 10:00

**Place:** Room 1 and 2

Mutation in the SARS-CoV-2 virus may lead to the evolution of new variants. The dynamics of these variants varied among countries. Identification of the governing factors responsible for distinctions in their dynamics is important for preparedness against future severe variants. This study investigates the impact of cross immunity and control measures on the competition dynamics of the Alpha, Gamma, Delta, and Omicron variants. The following questions are addressed using an n-strain deterministic model: (i) Why do a few variants fail to cause a wave even after winning the competition? (ii) In what scenarios a new variant cannot replace the previous one? The model is fitted and cross-validated with the data of COVID-19 and its variants for the USA, UK, and Brazil. The model analysis highlights implementations of the following measures against any deadlier future variant: (i) an effective population-wide cross-immunity from less lethal strains and (ii) strain-specific vaccines targeting the novel variant. The system exhibits a fascinating dynamical behaviour known as an endemic bubble due to Hopf bifurcation. It is observed that the actual situation in which Omicron won the competition from Delta followed by no wave due to Delta may turn into a competitive periodic coexistence of two strains due to substantial disparity in fading rates of cross-immunity. Global sensitivity analysis is conducted to quantify uncertainties of model parameters. It is found that examining the impact of cross-immunity is as crucial as vaccination. ([Back](#))

## Bounding Thermal Transport in Sea Ice

Noa Kraitzman  
Macquarie University

**Author(s):** Noa Kraitzman

**Time:** Mon 15:20

**Place:** Room 3

Understanding the linkage of scales in sea ice is a fundamental challenge for climate modelling. We investigate thermal conduction in sea ice in the presence of fluid convection, as an important example of an advection diffusion process in the polar regions. Using a new Stieltjes integral representation for the effective thermal conductivity, we derive a series of rigorous bounds obtained via Padé approximants in terms of the Péclet number. Our bounds are compared with experimental field data, providing new insights into convection enhanced thermal transport in sea ice. ([Back](#))

## Devil's terraces in a conceptual climate model with periodic forcing

Bernd Krauskopf  
The University of Auckland

**Author(s):** Bernd Krauskopf, John Bailie

**Time:** Mon 11:40

**Place:** Room 3

We consider the crucial vertical mixing process in the North Atlantic Ocean between warmer surface water and cold deep water, which drives the transport of warm water to Northern latitudes. The amount of fresh glacial meltwater varies with the seasons, and the conceptual model we study takes the form of a periodically forced planar vector field for (scaled) temperature and salinity with three parameters: the density threshold  $\eta$ , the virtual salinity flux  $\mu$ , and the strength  $c$  of the forcing. For  $c \geq 0$  there is an interaction between an intrinsic oscillation and the periodic forcing, which results in dynamics on an invariant torus. By computing the rotation number  $\rho$  over the corresponding region of the  $(c, \mu)$ -plane, we find the structure of resonance tongues where the dynamics is phase-locked. Since  $\rho$  is locally constant at rational values, its graph is a surface of devil's terraces with steps at irrational values of  $\rho$ . We present generic bifurcations of resonance tongues — that is, local changes to devil's terraces — that explain how the overall resonance structure changes with the parameter  $\eta$ . ([Back](#))

## Recursive Correction in Fluid Flow Modeling

Alexander Labovsky  
Michigan Technological University

**Author(s):** Mustafa Aggul, Alexander Labovsky

**Time:** Wed 12:00

**Place:** Room 4

We consider two predictor-corrector-type schemes for increasing the accuracy of the temporal discretizations of fluid flow problems, from first- to second-order. One of them is a known Deferred Correction (DC) idea of [1]; another was introduced recently in [5] and the author called it Recursive Correction (RC). We will test both approaches on a flow past a step, and on a fluid-fluid interaction problem (FFI), where two flows are coupled through a joint interface. The nonlinear coupling, known as the rigid lid condition, creates an extra level of difficulty, typical for atmosphere-ocean problems. Decoupling the FFI is desirable, as it reduces the size of the system and allows for the usage of legacy codes for the subdomains. The stable decoupling method of [2], that the authors called the Geometric Averaging method (GA), is only first order accurate. We will compare the GA-DC and the GA-RC methods in terms of their accuracy and efficiency. Both sets of tests show the superiority of the RC approach, and allow for a cautious optimism that the Recursive Correction could alleviate the long-standing curse of defect correction methods - the asymptotic nature of convergence, where the claimed convergence rates are only achieved at small time step sizes.

## References

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- [4] J. Burkardt, C. Trenchea, *Refactorization of the midpoint rule*, Applied Math. Letters, 107, 2020, 106438.
- [5] A. Labovsky, *Recursive Correction - a Novel Technique for Decoupling and Linearization of Navier-Stokes Systems*, under review in Computers and Mathematics with Applications, 2026.

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## Simulating emergency animal disease outbreaks and response: development and outcomes

Thao P. Le

The University of Melbourne

**Author(s):** Thao P. Le, Isobel Abell, Simon Firestone, Sarita Rosenstock, Chris Baker

**Time:** Tue 11:20

**Place:** Room 5

Outbreaks of animal diseases in Australia can cause significant impacts to animal populations and livestock industries. We developed and ran simulation exercises which simulated a hypothetical lumpy skin disease outbreak and provided decision-makers the opportunity to use forecasting tools as part of their simulated decision-process. This talk summarises the development process, key outcomes (see Isobel Abell's talk for more details!), and next steps. There will also be a little demo of the simulation exercise. ([Back](#))

## Rigorous numerical analysis in the age of vibe coding: case studies

Paul Charles Leopardi

Australian National University

**Author(s):** Paul Charles Leopardi

**Time:** Thu 10:00

**Place:** Room 4

Published papers on topic in numerical analysis and scientific computing are often accompanied by open source software that illustrates or implements the algorithms and methodologies discussed in the paper. While the algorithms and methodologies themselves can have long-lasting value, the accompanying open source software can be subject to technical debt, "bit rot" and premature obsolescence. Ideally, such software should be well-maintained by a team of scientific research software engineers, but for prototype-level software that may have been developed by one or a few university students or postdocs, some software maintenance tasks, such as porting to another language or another numerical library, may be unrealistic.

Recently, the use of Large Language Models in software development has become popular, especially in relation to commercial software, so much so that "vibe coding" is a new buzz-phrase.

This talk describes two case studies of "vibe coding" based on GitHub repositories that illustrate and implement concepts in computational mathematics and numerical analysis. These illustrate the crucial role that careful prompting, rigorous testing and debugging must play in current "vibe coding" projects for mathematical software.

1. The GitHub Copilot tool is being used to translate the `penguian/eq_sphere_partitions` Matlab code into Python at `penguian/eqsp` 2. The Google Antigravity system is being used to port the linear algebra libraries used by the `penguian/glucat` C++ code from uBLAS and Blaze to Eigen and Armadillo. ([Back](#))

## Estimating the impact of a school-based live-attenuated influenza vaccination program in Australia: a modelling study

Tiffany Leung  
UNSW Sydney

**Author(s):** Tiffany Leung, Isaac Stopard, James Wood, Alexandra Hogan

**Time:** Thu 10:20

**Place:** Room 6

Background: Australian and New Zealand government public health partners are interested in the potential impact of a school-based seasonal influenza immunisation program using an intranasally delivered live-attenuated influenza vaccine (LAIV). We aimed to evaluate the potential health impacts of this program.

Methods: We developed a mathematical model of seasonal influenza transmission and vaccination under an LAIV program with two targeted age groups. We calculated the number of averted infections, cases and hospitalisations due to influenza compared to baseline.

Results: An LAIV program targeting primary school children (5-11 years old) and all school-age children (5-17 years old) could reduce the attack rate to 7.4-8.8% and 5.7-8.3%, respectively, compared to 9.5% at baseline, at the population level. Equivalently, targeting primary school children could avert infections, cases and hospitalisations by 6-22%, 8-27% and 5-18%, respectively. Expanding the targeted age group to all school-age children could avert infections, cases and hospitalisations further by 12-39%, 15-47% and 11-34%, respectively, from baseline. The indirect benefit was sizeable, particularly in averted hospitalisations, of which 90% were in non-targeted age groups.

Interpretation: A school-based LAIV program has the potential to lower the annual attack rate of seasonal influenza and have substantial direct and indirect benefits. ([Back](#))

## Draw resonance in micro-structured optical fibre fabrication

Caitriona Lightbody\*  
The University of Adelaide

**Author(s):** Caitriona Lightbody, Yvonne Stokes, Michael Chen

**Time:** Mon 16:40

**Place:** Room 6

The fabrication of microstructured optical fibres involves drawing a heated preform to a desired diameter. This process is influenced by factors such as the draw and feed speeds, surface tension, inertia, applied pressure, heating and cooling. For some choices of these parameters, an instability known as 'draw resonance' develops that compromises a fibre's uniformity and, consequently, its optical properties. In this talk we present an extension on current mathematical models and investigate the onset of draw resonance in the case of fibre drawing where the glass is first heated within a heater region below which it is then cooled. ([Back](#))

## Integrating Ethnic Heterogeneity into Infectious Disease Transmission Models

Vincent Lomas \*  
University of Canterbury

**Author(s):** Vincent Lomas

**Time:** Mon 16:40

**Place:** Room 5

During the COVID-19 pandemic, Aotearoa followed an elimination strategy followed by a mitigation strategy, which saw high success and kept health impact low. However, there were inequities in health outcomes, notably that Māori and Pacific Peoples had lower vaccine coverage and experienced higher age-standardised rates of hospitalisation and death. Despite these inequities in health outcomes, most mathematical models have not explicitly considered ethnic heterogeneities as factors. We developed such a model to investigate the first Omicron wave of the COVID-19 pandemic in Aotearoa, which was the first widespread community transmission of SARS-CoV-2. We then fit our model by using ethnicity-specific data on reported cases and spatially disaggregated population counts. We found that in our model differences in transmission rates were required to explain the disparity in health outcome and that Māori and Pacific transmission rates were higher than the Asian and European/Other rates. We then developed a general method to stratify these models with multiple demographic factors which showed differences in epidemic outcome that are obscured by other models. ([Back](#))

## When hosts gather: how extreme seasonal aggregation affects epidemiological outcomes

Daniel Longmuir \*  
RMIT University

**Author(s):** Daniel N. Longmuir, Simon Johnstone-Robertson, Roslyn I. Hickson, Stephen A. Davis

**Time:** Mon 17:00

**Place:** Room 5

Wildlife aggregate for many reasons (e.g. reproduction, feeding) and at times these aggregations can be extreme, with host densities increasing several orders of magnitude. While the impact of seasonality on infectious disease dynamics is well studied, few—if any—studies have explicitly examined how extreme aggregation affects key epidemiological outcomes. Here we consider an epidemic in a closed SIR (Susceptible–Infectious–Recovered) metapopulation with a hub–satellite structure, where seasonal movement into the hub follows a modified Gaussian function. We numerically explore how aggregation duration and timing shape two outcomes: final size and peak prevalence. We find a narrow set of circumstances and pathogens for which even extreme aggregation materially alters these outcomes. When aggregation coincides with, or begins just prior to, infection introduction, aggregation can strongly affect pathogens with  $R_0 \approx 1$  or  $R_0 < 1$ , enabling epidemics that would otherwise fade. Effects are strongest under density-dependent transmission, where contact rate scales with local density; frequency-dependent transmission renders aggregation negligible. High transmissibility ( $R_0 \gg 2$ ) minimises aggregation's impact because most susceptibles are infected regardless of density changes. ([Back](#))

## Stokes' Phenomenon Within a Small-Time Boundary Layer

Christopher Lustri  
The University of Sydney

**Author(s):** Christopher Lustri

**Time:** Mon 17:20

**Place:** Room 4

The 5th-order KdV equation is a PDE that describes shallow water waves with surface tension. The steady version of this problem is a canonical ODE problem in exponential asymptotics, studied by Akylas, Grimshaw & Joshi, and others, who demonstrated that the (symmetric) steady solution is unstable and cannot be reached by the time-varying PDE. Instead, the PDE features a burst of waves that propagate in one direction and cannot be described by the steady-state solution. With the advent of exponential asymptotics for PDEs, it is now possible to understand the evolution of the PDE system: the appearance of these rapidly propagating waves occurs due to Stokes' phenomenon in a small-time boundary layer. I will demonstrate the Stokes structure and show the form of these rapidly propagating waves. ([Back](#))

## Gamifying data visualisation: Teaching ggplot2 through competitive code golf

Michael Lydeamore  
Monash University

**Author(s):** M. J. Lydeamore

**Time:** Tue 10:20

**Place:** Room 3

Code golf—writing the shortest possible code to solve a problem—has emerged as an engaging method for teaching programming fundamentals. Its competitive, game-like structure fosters student motivation and encourages self-directed learning.

Inspired by the success of CSSBattle, which attracts thousands of daily users with CSS challenges, I present ggplot Battles: a new browser-based platform designed to teach data visualisation using R's ggplot2 package. Participants are given a target plot and a predefined dataset, then challenged to recreate the plot as closely as possible.

Built with WebR, the platform runs entirely in the browser with no local R setup required. I discuss the pedagogical value and potential for fostering concise and accurate data visualisation skills. ([Back](#))

## Two Acts in One: The Actin Model That Couldn't, And The One That... Could?

Matthew Mack\*  
University of South Australia

**Author(s):** Matthew Mack

**Time:** Wed 12:20

**Place:** Room 6

Clearing actin out of the extracellular matrix for improved wound-healing outcomes means taking a closer look at the structure of actin and the other proteins it interacts with. However, will modelling attempts during the first year of my PhD result in fruitful progress? Will the models themselves be sufficient for the experimental data to come? Tune in to find out! ([Back](#))

## Modelling the population dynamics of arbovirus vector *Culex Annulirostris* in southeastern Australia

Cooper Maher\*  
RMIT University

**Author(s):** Cooper R. Maher, Simon P. Johnstone-Robertson, Peter A. Durr, Stephen A. Davis

**Time:** Wed 10:00

**Place:** Room 6

*Culex Annulirostris* is a mosquito vector for several arboviruses in Australia, including Japanese Encephalitis Virus, Ross River Virus and Murray Valley Encephalitis. Mosquito abundance is a fundamental measure of risk of infection to humans. However, to date there is no published model in the literature that predicts *Culex Annulirostris* dynamics in southeastern Australia. We propose and compare the output of 4 such models to mosquito abundance data collected near Echuca between 1979 and 1985. These models vary in their considerations of environmental factors. Models fits show reasonable levels of correlation with a Pearson correlation coefficient around 0.6. By comparing the models, we observe that to capture the trends of abundance it is essential to consider the hydrology in an environment. ([Back](#))

## A Design of Distributed Controllers for Linear Nonautonomous Multi-Agent Systems

Kaname Matsue  
Kyushu University

**Author(s):** Kaname Matsue, Ugochukwu James Nwebonyi and Dinh Hoa Nguyen

**Time:** Mon 17:00

**Place:** Room 3

This talk aims at providing a strategy to construct feedback gains in multi-agent systems so that both local and global dynamics achieve disciplined behaviour, such as "consensus", during time evolution. Now each internal state called agent is supposed to follow linear dynamical system, and neighbouring agents are communicated each other to construct network. Our significance here is treatment of time-variant linear coefficients expressing unexpected injury or breakdown of agents and temporal switching of networks expressing occasional failure of communications, and achievement of consensus under these situations. ([Back](#))

**Linking intra-host parasite dynamics, transmission and epidemiological dynamics to evaluate the public health utility of alternative drug regimens for *Falciparum* malaria.**

James McCaw

The University of Melbourne

**Author(s):** James M McCaw, Xiao Sun, Pengxing Cao

**Time:** Mon 10:40

**Place:** Room 5

Malaria remains a public health burden affecting billions of people worldwide, and the transmission of malaria parasites from human hosts to mosquitoes is an essential step in the life cycle of the parasite.

In this study, we developed a stochastic model of human-to-mosquito transmission which integrates intra-host parasite dynamics in both human and mosquito hosts and fit the model to data from a direct feeding assay in a human challenge study. Then, by embedding these intra-host dynamics and the transmission probability (per bite) in an epidemiological transmission dynamics framework, we explore the clinical and population level impacts of alternative treatment strategies.

By incorporating the pharmaco-kinetic–pharmaco-dynamic (PK–PD) properties of both artemisinin-based therapies and gametocytocidal drugs such as primaquine at the host scale, we are able to study the impact of treatment strategies as an emergent property of our multi-scale analysis. This avoids the need to introduce an epidemiological-scale parameterisation of drug effectiveness. We find clear evidence for both a clinical and population level benefit due to the use of primaquine, and relate these findings to observations from field trials. ([Back](#))

**Exponential asymptotics, dispersive waves and the KdV equation**

Scott McCue

Queensland University of Technology

**Author(s):** Scott McCue

**Time:** Mon 11:40

**Place:** Room 5

Solutions of the KdV equation on the real line are characterised by a finite number of solitons moving to the right plus dispersive waves that travel to the left. For initial conditions that are analytic functions of  $x$ , the amplitude of these dispersive waves is exponentially small as  $t \rightarrow 0^+$  and therefore cannot be captured by a naive perturbation expansion in powers of  $t$ . Instead, these waves can be described using exponential asymptotics, as I will explain. ([Back](#))

## Mathematical Modelling of Pertussis Dynamics and Impact In Aotearoa New Zealand

Hannah McGregor \*  
The University of Auckland

**Author(s):** Hannah McGregor, Dr Oliver Maclaren, Dr Janine Paynter, Prof Michael Plank

**Time:** Tue 12:20

**Place:** Room 5

Pertussis (whooping cough) remains a significant public health concern in Aotearoa New Zealand, with epidemics recurring every 3-5 years despite widespread vaccination. Infants and young children are most affected, with Māori populations experiencing disproportionately high hospitalisation rates. At least 11 infant deaths have been attributed to pertussis in the past two decades, and COVID-19 disruptions have worsened immunisation gaps. Currently, up to one-third of infants under six months are insufficiently immunised, rising to one-half among Māori infants.

New Zealand lacks mathematical models of pertussis transmission, limiting the ability to evaluate vaccination strategies and anticipate epidemics. The true disease burden is further underestimated due to underreporting, especially among adults with mild or atypical symptoms.

We will develop a compartmental SIRW (Susceptible-Infected-Recovered-Waning immunity) model incorporating vaccination, age, and ethnicity structure, parameterised using administrative health data on notifications, hospitalizations, immunization, and social contact patterns. Model fitting will employ likelihood-based methods with identifiability analyses to address challenges from underreporting and asymptomatic cases.

The model will quantify transmission dynamics across age groups and ethnic populations, identify key drivers of infection, and estimate vaccination thresholds needed to understand pertussis epidemics.

This framework will provide essential evidence to optimise vaccination strategies and strengthen epidemic preparedness in New Zealand. By utilising administrative health data with mathematical modelling, it will inform policies to reduce pertussis burden, particularly among vulnerable infants and Māori communities. ([Back](#))

## Linear Wave Scattering by a Beach

Mike Meylan  
The University of Newcastle

**Author(s):** Mike Meylan

**Time:** Wed 12:20

**Place:** Room 5

In this talk, I will present recent research on linear wave scattering by a beach. This models the interaction of low-amplitude, low-period waves, which are primarily reflected rather than dissipated by breaking as they approach the beach. I will begin with the classical problem of scattering by a beach of constant slope, which can be solved using the Mellin transform. I will then discuss numerical methods for variable bathymetry based on the boundary element method. This is joint work with Gennady Mishuris. ([Back](#))

## Thermal performance curve models calibrated to ecological data using Sequential Monte Carlo sampling: an application to Antarctic moss photosynthesis

Elise Mills

Queensland University of Technology

**Author(s):** Elise Mills, Eliza Domann, Diana King, Alicia Perera-Castro, Krystal Randall, Sharon Robinson, Jane Wasley, and Matthew Adams

**Time:** Thu 10:00

**Place:** Room 5

A range of moss species form the primary terrestrial vegetation inhabiting the Antarctic continent. Moss growth is driven by photosynthesis, which is highly responsive to its surroundings. Photosynthesis models incorporating a dependence on light, temperature and water content could provide valuable information about how a changing environment can moss survival, growth and species distribution; existing models typically depend on only one of these quantities.

We propose two thermal performance curve models with a dependence on all three of these biologically relevant factors. Two types of model formulation were used: Liebig's law of the minimum, and a multiplicative approach. However, the available data (six different moss species in total, taken from different locations in Antarctica) does not explicitly consider the interaction of light or temperature with water content. We therefore use Sequential Monte Carlo sampling, first to calibrate a portion of the proposed model to data comprising light and temperature, and second to separately calibrate a second portion of the model to data comprising water content; this approach justifies our choice of model construction in order to represent the photosynthesis response of moss to all three factors. We considered the performance of the different models and formulations, as well as the identifiability of the model parameters.

We demonstrate that the models can estimate key parameters of moss photosynthesis, and that these parameters are identifiable and consistent with previous studies. Our preliminary results indicate that key parameters can differ vastly between moss species. It is intended that the models, fully calibrated including rigorous quantification of uncertainty, have utility in forecasting the responses of these unique Antarctic plants to climate change. ([Back](#))

## Coupling estimation in synchronized oscillators using spike timing data

Fumito Mori

Kyushu University

**Author(s):** Fumito Mori, Takahiro Iwami, Hiroshi Kori, Hiroshi Ito

**Time:** Mon 17:20

**Place:** Room 3

Biological systems exhibit diverse rhythms, such as circadian rhythms and heartbeats, which can be modeled as interacting oscillators. Stable rhythms under noisy conditions are maintained through synchronization among oscillators. When two oscillators appear well synchronized, this may result from either strong coupling or weak noise. This raises the question of whether coupling strength and noise intensity can be distinguished. In Ref. [1], we developed a method to simultaneously estimate coupling strength and noise intensity using only oscillation timing data, based on a stochastic coupled phase oscillator model. The method has been extended to systems with asymmetric coupling. Furthermore, we have constructed an experimental setup using asymmetrically coupled metronomes to validate the theory.

[1] Fumito Mori and Hiroshi Kori, Proceedings of the National Academy of Sciences 119 (6), e2113620119 ([Back](#))

## A finite element based solver for studying large scale groundwater dynamics

Liam Morrow  
Australian National University

**Author(s):** Liam Morrow

**Time:** Mon 12:40

**Place:** Room 6

Mathematical models play a vital role in hydrological forecasting and water management, particularly regarding the understanding of the long-term behaviour of groundwater flow. One of the most commonly studied models of groundwater flow is Richards' equation, which describes the movement of water in both unsaturated and saturated soils. Despite its importance, this equation is generally avoided in continental-scale modelling due to its recognised computational difficulty. Here we present a novel, open-source numerical package for solving Richards' equation in three dimensions that is suitable for studying groundwater flow at a variety of spatial scales. Our solver utilises Firedrake, a flexible software package for solving partial differential equations via the finite element method. We demonstrate how our solver can easily handle small scale problems (order of metres) efficiently and accurately. We then present a large-scale case study of groundwater flow in the Lower Murrumbidgee basin, which has an area of around 3600 km squared. Our simulation incorporates data made available by the Bureau of Meteorology (BoM) to model the stratigraphy of the basin, which consists of three layers of varying depth, as well as estimates of annual rainfall and current depth to water table. We show that our solver can accurately simulate flow dynamics over decades at a spatial scale well beyond previous studies.

[\(Back\)](#)

## A coarse-grained mathematical model for colorectal crypt dynamics

Ryan Murphy  
Adelaide University

**Author(s):** Ryan J Murphy

**Time:** Thu 10:40

**Place:** Room 1 and 2

Colorectal crypts are essential to the healthy function of the colon and their dysregulation is associated with cancer progression. To maintain homeostasis within each crypt multiple physical and biological processes occur on a range of overlapping spatial and time scales. We explore how cellular mutations, which can lead to cancer progression, influence population-level changes to crypt structure and function. We develop and explore a stochastic individual-based model of colorectal crypt dynamics capturing key biological processes. Using coarse-graining techniques, we derive the corresponding continuum model. The discrete model allows us to capture stochastic effects, for example due to cell division. In contrast, the continuum model allows us to determine the mean behaviour more efficiently than averaging many realisations of the discrete model. Comparing results from the discrete model and the corresponding continuum model we find parameter regimes with excellent agreement. [\(Back\)](#)

## Heart attacks and strokes; why (mathematical) cholesterol matters

Mary Myerscough  
The University of Sydney

**Author(s):** Mary Myerscough and Michael Watson

**Time:** Mon 10:20

**Place:** Room 1 and 2

What you see, depends on what's in your model.

We illustrate this truism by considering models for the formation of atherosclerotic plaques. These are fatty deposits that form in the lining of large arteries. These plaques are initiated by an immune cell response to cholesterol-bearing particles, but their dynamics are ultimately driven by cell behaviours.

Using a very basic example, followed by a more complex scenario, we show how modelling not just the cells in the plaque, but also the cholesterol that the cells contain, changes our understanding of plaque growth and development. ([Back](#))

## Towards a model for growth-induced wrinkling in thin elastic sheets

Daniel J Netherwood  
The University of Adelaide

**Author(s):** Danny Netherwood, Alex Tam, Doireann O'Kiely, Ben Binder, Edward Green

**Time:** Thu 10:20

**Place:** Room 3

In this work, we investigate growth-induced wrinkling morphologies that may be observed when a growing thin film expands along an underlying substrate. We develop an asymptotic mechanical model in which the sheet in its reference configuration is modelled as a spatially-reduced linear two-dimensional morphoelastic plate whose displacements are governed by the Föppl Von Kármán equations. Under the assumption of homogeneous in-plane isotropic growth, the sheet's axisymmetric expansion is opposed by friction between the sheet and the substrate, leading to the buildup of compressive stress, which the sheet alleviates by buckling out of plane, decorating the sheet with wrinkles. Valid within an asymptotic regime for which the sheet is of low bending stiffness, and that friction between the sheet and the substrate is weak, we find that forces between neighbouring material circles are weak, resulting in a decoupling whereby wrinkles along a given material circle may be investigated in isolation. We exploit this decoupling to show that the wrinkle dynamics along a given material circle are governed by a remarkably simple fourth-order ODE. We find that our results are valid outside of a boundary layer within which the far-from-threshold approximation breaks down. ([Back](#))

## Habituation Mechanism in the True Slime Mold via a Spatially Discretized Reaction–Diffusion Model

Kota Nishi\*  
Kyushu University

**Author(s):** Kota Nishi, Atsushi Tero, Yukinori Nishigami, Toshiyuki Nakagaki

**Time:** Wed 09:40

**Place:** Room 1 and 2

Habituation is a form of learning characterized by a decrease in response following repeated stimulation and has been observed in a wide range of organisms, from mammals to unicellular organisms. The true slime mold, *Physarum polycephalum*, is an amoeba-like unicellular organism renowned for its sophisticated adaptive responses to environmental stimuli. This study focuses on habituation to chemical stimuli reported in slime molds. We developed a mathematical model to describe the slime mold's locomotion driven by internal viscous fluid flow. The flow is generated by spatial gradients in fluid pressure. Accordingly, we formulated a system of ordinary differential equations with three variables: the position of the slime mold tip,  $\ell(t)$ , and the fluid pressures at the front and rear parts,  $p_f(t)$  and  $p_r(t)$ . Numerical simulations revealed that the trajectory in the  $p_f$ - $p_r$  phase plane plays a crucial role in generating habituation behavior. Furthermore, a simple variable transformation demonstrated that the total amount of chemical substances controlling the fluid pressure encodes the history of external stimulation. ([Back](#))

### Hunting Dragons: non-unique parameter estimates arise from numerical error in longitudinal models

Tess O'Brien

University of New South Wales

**Author(s):** Tess O'Brien

**Time:** Wed 11:40

**Place:** Room 4

When numerical methods are used for longitudinal models of dynamics, estimation of parameters is conditioned on numerical error in addition to the data and underlying model. Here I present a novel source of non-uniqueness for linear ordinary differential equation parameters that arises from numerical error, and discuss the next moves to determine whether this is a widespread problem. ([Back](#))

### Mechanochemical Axis Formation in Hydra Spheroids

Dietmar Oelz

The University of Queensland

**Author(s):** Dietmar Oelz

**Time:** Wed 12:00

**Place:** Room 1 and 2

The spontaneous emergence of tissue patterns is often attributed to biochemical reaction-diffusion systems. In Hydra tissue regeneration, the formation of a Wnt signaling center exemplifies this process. However, a strictly biochemical mechanism for self-organization in Hydra remains elusive. In this study, we investigated mechanical stimuli and identified a positive feedback loop between Wnt signaling and tissue stretching. We developed a mathematical model of mechanochemical pattern formation in a closed elastic shell, representing regenerating Hydra epithelial spheroids. Our model explains how mechanical forces drive axis formation and predict the organizer's location under various perturbations. ([Back](#))

### An agent-based and blood flow model of vascularisation in endometriotic lesions.

Cecilia Olivesi\*

The University of Auckland

**Author(s):** Cécilia Olivesi, Prof. Alys Clark, Dr Claire Miller

**Time:** Mon 10:20

**Place:** Room 6

Endometriosis is a condition defined by the presence of endometrial-like tissue growing outside the uterus and impacts 1 in 10 women of reproductive age. Endometriotic lesions require blood supply to implant and grow. Clinically, these lesions are categorised based on characteristics related to vascularisation, which is established via angiogenesis and triggered by angiogenic factors such as vascular endothelial growth factor (VEGF).

An agent-based model of angiogenesis is used to analyse the influence of the spatial profile of VEGF, which depends on the VEGF source (the lesion or its surrounding tissue), on network characteristics. A continuum model is used to describe VEGF concentration in the microenvironment of an endometriotic lesion. We model the blood flow through the final vascular network using Poiseuille's law. We couple the models through the sprouting probability (the probability of a new vascular branch), which depends on the VEGF concentration.

Our model shows that survival prospects are increased for a VEGF gradient source situated inside the lesion. However, the network has increased complexity for an increased baseline VEGF around the lesion. Based on our study, we hypothesise that different VEGF profiles could explain the heterogeneity in endometriotic lesion vascular networks. In the future, we aim to use lesion imaging to compare and validate these results against different lesion types. ([Back](#))

### **Phase resetting in a system of coupled Van der Pol oscillators**

Hinke Osinga

The University of Auckland

**Author(s):** Hinke M. Osinga, Kyoung Hyun Lee, Neil Broderick and Bernd Krauskopf

**Time:** Mon 12:00

**Place:** Room 3

Coupled nonlinear oscillators are found in many application contexts; specific examples in photonics are coupled optical cavities and ring resonators. Synchronisation properties of such systems can be probed by studying the response to external perturbations: after relaxation back to the stable oscillation, there is generally a phase shift. Important information can be gained by studying such phase resets as a function of when the perturbation is applied during the oscillation.

We present a case study of a prototypical example: two coupled 1:1 phase-locked Van der Pol oscillators. In contrast to single oscillators, this system has a phase space of dimension four. In particular, the basin of attraction of the stable synchronised oscillation has a complicated boundary, and we show how this affects the observed phase resetting in unexpected ways. ([Back](#))

### **Exploring the Dynamics of Uterine Smooth Muscle Fibre Contraction Using Agent-Based Modelling.**

Lata Paea \*

The University of Auckland

**Author(s):** Lata Paea, Alys Clark, Claire Miller

**Time:** Wed 11:20

**Place:** Room 6

The uterus has two layers of smooth muscle cells, organized in fibres, whose main function is to produce contractions. These contractions require calcium, which is transported to the cell's

contractile machinery via electrical stimulation and movement of ions in and out of the cells. Disruptions in electrical signal propagation between and into cells can lead to changes in contraction strength, coordination, and direction, and this may influence menstrual flow patterns. Disruption in menstrual flow could contribute to retrograde menstruation, where menstrual blood and tissue flow backwards and enters the pelvic cavity, potentially leading to a disease called endometriosis. Investigating these contractile patterns may help verify mechanisms that contribute to retrograde menstruation. We can use mathematical modelling to explore how dysfunctions in electrical signal propagation influence contraction dynamics in uterine smooth muscle fibres.

We present an agent-based model coupled with a cell model of contraction activation and force generation to link the electrophysiological process to the mechanical dynamics of the muscle fibre. We will present two coupling approaches. In the first approach, the intracellular calcium concentration drives active force generation via a Hill function. This is a simpler approach that captures the calcium-force relationship without adding to model complexity, but this could be a limitation when trying to examine complex or non-linear behaviours. In the second approach, we consider a contractile machinery force function where the cell contractile elements are explicitly modelled for the active force generation. This provides a more biologically detailed representation of the contractile mechanisms in smooth muscles and may allow more accurate predictions of force generation. However, it introduces more parameters, more variables, and increased requirements for parameterization. We present both approaches and examine how added complexity changes the system dynamics. We will also explore how muscle fibre dynamics change in response to variations in intracellular calcium concentration between two models. ([Back](#))

### Mathematical approaches for refining metabolic maps of *Leishmania* parasites

Michael Pan  
UNSW Sydney

**Author(s):** Michael Pan

**Time:** Wed 10:00

**Place:** Room 1 and 2

Leishmaniasis is a tropical disease caused by infections from *Leishmania* parasites, which are transmitted from sandfly bites. There is currently no vaccine for leishmaniasis, and significant attention has been directed towards developing drugs that target the metabolism of *Leishmania*. Recent advances in 13-carbon metabolomics experiments are capable of providing insights into how *Leishmania* parasites utilise nutrients. However, unlike many organisms, the metabolic network of *Leishmania* has not been completely mapped. This is an issue because established modelling approaches using this data (such as metabolic flux analysis) rely on an accurate representation of the metabolic network.

In this talk, we explore a few approaches for testing the consistency of current metabolic representations of glucose metabolism in *Leishmania* against 13-carbon isotope labelling data, using simple ordinary differential equation (ODE) models. An analysis of labelling timescales reveals surprisingly slow glucose labelling (~60 minutes) relative to downstream metabolites such as 6-phosphogluconate (~3 minutes), which cannot be explained with kinetic models using a standard representation of central carbon metabolism. We hypothesise that this apparent misordering of timescales can be accounted for by introducing a compartmentalisation mechanism in our model, where glucose is divided into smaller subpools that are experimentally indistinguishable.

Our initial modelling suggests that glucose enters a small subpool capable of entering glycolysis and pentose phosphate pathway, prior entering the bulk glucose pool. We discuss how this finding can be reconciled in the context of current knowledge of *Leishmania* metabolism and be used to improve the accuracy of future metabolic reconstructions. ([Back](#))

### Inferring critical transitions from timeseries

Davide Papapicco\*  
The University of Auckland

**Author(s):** Davide Papapicco

**Time:** Mon 12:20

**Place:** Room 3

Critical transitions (or tipping points) are sudden, abrupt and often unforeseen departures of states of a dynamical system from a regime of stable equilibrium. In the past 20 years, tipping points have been an ever increasing studied subject in climate science and ecosystems given how disruptive these events can be. Mathematical characterisation of tipping points happened more recently with an tentative classification into three different mechanisms being proposed in 2012 by Ashwin et al.: bifurcation (B-tipping), noise (N-tipping) and rate (R-tipping) induced. Lately, more and more efforts from the community have shifted towards the robust and reliable prediction of these transitions in the form of early-warning signals (EWS). In this talk we will discuss one recent statistical method to derive an EWS from a large deviation principle using only timeseries data prior to a saddle-node type bifurcation. ([Back](#))

### A Unified Kinetic-Thermodynamic Model of Solid Dissolution Predicting Critical Threshold for Dissolution Failure

Haewoon Park\*  
The University of Sydney

**Author(s):** Haewoon Park

**Time:**

**Place:**

We have developed a novel mathematical model that integrates dissolution kinetics and a thermodynamic saturation limit, thereby enabling prediction of dissolution failure. Understanding dissolution of solids from both kinetic and thermodynamic perspectives is paramount in various applications including pharmaceuticals. However, existing models consider dissolution kinetics and solubility separately, rendering it difficult to predict possible dissolution failures. In this study, a mathematical formula was developed by mathematically integrating the two components, and this revealed that above a critical effective temperature parameter, corresponding to an energy value of  $Q \approx 0.36$ , the saturation equation has no real solution. For  $Q < 0.36$ , the model provides predictions for finite dissolution times and a well-defined saturation point. This leads to a discovery that dissolution becomes impossible even in the presence of continued mass transfer. Furthermore, the mathematical integration resulted in a separable ordinary differential equation. A convergence test was performed on the integral, which revealed that the solution concentration approaches saturation asymptotically. Furthermore, other mathematical analyses have been performed to reveal non-trivial findings. It also revealed that the equilibrium state disappears entirely when the temperature value exists. These findings may aid in the formulation and successful delivery of poorly-soluble drugs, where dissolution is the rate-limiting step for bioavailability. ([Back](#))

### Developing new technologies in changing environments

Luz Pascal\*  
Queensland University of Technology

**Author(s):** Luz Pascal

**Time:** Tue 11:20

**Place:** Room 3

New technologies are an attractive opportunity to help address some of our most pressing crises, such as climate change, biodiversity loss, and emerging diseases. However, many of these challenges evolve in a changing environment, requiring investments to be tailored to these changes. In this talk, I will present a new model from stochastic optimization to make informed Research and Development (R&D) decisions in changing environments. Using the example of developing new technologies for preserving Australia's Great Barrier Reef under climate change, I will demonstrate the importance of accounting for changes in the environment when making R&D investments. In particular, I will show that if we ignore changes in the environment we might make irrational decisions. In some situations, we might over invest in a technology, wasting our scarce resources, or under invest, risking to miss out on opportunities to obtain a valuable technology.

[\(Back\)](#)

### **An Agent-Based Approach to Modelling Antimicrobial Interactions with Bacterial Populations**

Aidan Patterson \*

University of South Australia

**Author(s):** Aidan Patterson, Alex Tam, Judy Bunder, Bronwyn Hajek, Ryan Murphy

**Time:** Mon 10:00

**Place:** Room 6

Biofilm removal using antimicrobial agents such as silver nanoparticles motivates the development of models that capture how these agents interact with spatially structured bacterial populations. Antimicrobial effectiveness depends not only on biomechanical action but also on spatial and stochastic factors that govern how agents encounter bacteria. This work presents a two-dimensional agent-based model that simulates a bacterial population exposed to antimicrobial agents. Simulations of the model describe bacterial elimination over time, and the spatial clustering of surviving bacteria. Future work will involve Bayesian parameter inferences using experimental images, which will help to determine biological parameters and optimise antimicrobial treatment. [\(Back\)](#)

### **Is it over yet? Estimation of end-of-outbreak probabilities**

Michael Plank

University of Canterbury

**Author(s):** Plank, Michael J.

**Time:** Mon 16:20

**Place:** Room 5

Towards the end of an infectious disease outbreak, when a period has elapsed without new case notifications, a key question for policymakers is whether the outbreak can be declared over. This requires the benefits of a declaration (e.g. relaxation of outbreak control measures) to be balanced against the risk of a resurgence in cases. To support this decision-making, mathematical methods have been developed to quantify the end-of-outbreak probability using surveillance data in real-time.

Here, we propose such a method that accounts for some of the important features of real-world outbreaks: (i) incomplete case ascertainment; (ii) reporting delays; (iii) individual heterogeneity

in transmissibility; and (iv) whether cases were imported or infected locally. We showcase our approach using two outbreak case studies: Covid-19 in New Zealand in 2020 and Ebola virus disease in the Democratic Republic of the Congo in 2018. In these examples, we found that the date when the estimated probability of no future infections reached 95 percent was relatively consistent across a range of modelling assumptions. This suggests that our modelling framework can generate robust quantitative estimates that can be used by policy advisors, alongside other sources of evidence, to inform end-of-outbreak declarations. ([Back](#))

### **Non-Classical Symmetries and Non-Lie Solutions with Biological Growth Rate Functions to a Class of Nonlinear Reaction-Diffusion Equations**

David Plenty \*

University of Wollongong

**Author(s):** David Plenty and Maureen P. Edwards

**Time:** Mon 16:40

**Place:** Room 4

Classical Lie and non-classical symmetry analyses are valuable tools for finding exact solutions to partial differential equations. Non-classical symmetries can sometimes give rise to non-Lie solutions, that is, those that cannot be captured by standard classical Lie point symmetries.

In this talk, I present a variety of non-classical symmetries and non-Lie solutions of a class of nonlinear reaction-diffusion equations. These equations are shown to admit solvable symmetry reductions when the reaction terms assume various biological growth rate functions. The non-classical symmetries give a special link between the diffusivity and the spatially dependent component of the reaction term, through which one can exploit to obtain a desired diffusivity for the application under consideration. ([Back](#))

### **Three-dimensional characteristics of the movements of dinoflagellates; a multi-disciplinary investigation**

Olle Ponten \*

The University of Melbourne

**Author(s):** Olle Ponten, Douglas Brumley

**Time:** Tue 10:20

**Place:** Room 1 and 2

Dinoflagellates are an ecologically important group of marine microalgae capable of exhibiting rich responses to light stimuli and chemical gradients. Their motility is attained through the beating of two flagella, one transversal flagellum girdling the cell and a longitudinal flagellum behind the cell. However, the emergent helical trajectories are difficult to characterise owing to their three-dimensionality, high swimming speeds of cells, and the fragility of the temporary flagella. Using a stereoscopic microscopy platform, we tracked cells in three dimensions for multiple seconds over several millimetres, allowing us to extract quantitative features of the helical trajectories. Combining this with high-speed imaging (2000 fps) of the flagella on immobilized cells, together with hydrodynamic modelling of single cells in the zero Reynolds limit, we explicitly link the meso-scale characteristics of the trajectories to the individual flagellar motion. We use this multi-pronged approach to investigate differences in the motility among multiple strains of the coral endosymbiont Symbiodiniaceae including those which have undergone selection for higher temperature for use in coral restoration and resilience. ([Back](#))

## Why Cultural Change Repeatedly Triggers Disease Emergence

Pantea Pooladvand  
The University of Sydney

**Author(s):** Pantea Pooladvand, Jeremy R. Kendal, Mark M. Tanaka

**Time:** Tue 12:40

**Place:** Room 5

Human cultural practices that are perceived as adaptive, from land clearing to medical innovations, can spread rapidly through populations while unintentionally creating conditions that favour disease emergence. This work asks two related questions: what population level processes link cultural change to pathogen emergence, and which combinations of human practices have historically driven this process?

We develop a mathematical model showing that once a risky practice becomes established, disease emergence can be difficult to avoid. Social learning accelerates emergence on average, but stochasticity remains high unless the practice confers a strong fitness advantage. A complementary cluster analysis of 44 infectious diseases reveals that emergence is driven by recurring combinations of human practices, linking domestication, wildlife contact, and movement in distinct ways.

Together, these approaches show that cultural evolution creates recurring pathways to disease emergence, and that identifying these pathways can inform where future emergence risk is likely to arise. ([Back](#))

## The effect of self-induced Marangoni flow on polar-nematic waves in active-matter systems

Andrey Pototsky  
Swinburne University of Technology

**Author(s):** Andrey Pototsky and Uwe Thiele

**Time:** Mon 12:00

**Place:** Room 6

We study the formation of propagating large-scale density waves of mixed polar-nematic symmetry in a colony of self-propelled agents that are bound to move along the planar surface of a thin viscous film. The agents act as an insoluble surfactant, i.e. the surface tension of the liquid depends on their density. Therefore, density gradients generate a Marangoni flow. We demonstrate that for active matter in the form of self-propelled surfactants with local (nematic) aligning interactions such a Marangoni flow nontrivially influences the propagation of the density waves. Upon gradually increasing the Marangoni parameter, which characterises the relative strength of the Marangoni flow as compared to the self-propulsion speed, the density waves broaden while their speed may either increase or decrease depending on wavelength and overall mean density. A further increase of the Marangoni parameter eventually results in the disappearance of the density waves. This may occur either discontinuously at finite wave amplitude via a saddle-node bifurcation or continuously with vanishing wave amplitude at a wave bifurcation, i.e. a finite-wavelength Hopf bifurcation. ([Back](#))

## Rate-induced tipping and delay: examples and challenges through the lens of a paleoclimate model

Courtney Rose Quinn  
University of Tasmania

**Author(s):** Courtney Quinn  
**Time:** Mon 12:40  
**Place:** Room 3

The phenomenon of rate-induced tipping has gained much attention over the past decade, particularly in studying the evolution of ecological and climate systems. This is primarily motivated by the rapidly changing environmental conditions due to human behaviour. Most of the literature has focused on systems of ordinary differential equations (ODEs) where the dynamics are dependent on the system state at its current time. In the multiscale problems that often arise in these natural systems, there exists the possibility of delayed feedback effects in which past behaviour can impact the present time dynamics. Such feedback can be captured by delay differential equations (DDEs) where solutions require a continuous history of the system. The aforementioned rate-induced tipping has not been widely studied in DDEs which are infinite dimensional in nature. In this talk I will present an illustrative example of a DDE model for ice age cycles which has an ODE counterpart. I will show the existence of rate-induced tipping and discuss how some of the theory developed for ODEs can be extended to DDEs. Observations where the systems' responses diverge will be explored. ([Back](#))

### **The numerical challenges of modelling the erosion of complex landform**

Llewyn Randall \*  
Griffith University

**Author(s):** Llewyn Randall  
**Time:** Tue 11:20  
**Place:** Room 4

Amphitheatre gullies are complex landforms which present a unique modelling challenge for modellers. To capture the hydraulic and sediment transport behaviour in a system with changing geometry, is a problem which easily encounters numerical instability. The discontinuous Galerkin method has been used previously with success for solving the shallow water equations with the wet-dry transitions and shock fronts often observed in such a system. Here, I present a breakdown of the numerical methods used to solve the system of differential equations for a two-dimensional gully erosion model. Particular attention will be paid to the shortcomings of other numerical methods and the implications the results for this model has for intervention. ([Back](#))

### **The potential for re-vegetation to mitigate climate change effects on gully growth in Queensland.**

Melanie Roberts  
Australian Rivers Institute, Griffith University

**Author(s):** Melanie Roberts  
**Time:** Tue 11:40  
**Place:** Room 4

Climate change is projected to intensify rainfall extremes across Queensland, increasing the risk of gully erosion and sediment delivery to sensitive ecosystems such as the Great Barrier Reef. Gully erosion is a major contributor to poor water quality, yet its response to future climate remains uncertain. This study uses the process-based MERGE gully erosion model to assess how projected rainfall changes under three climate scenarios might influence erosion in four gullies across South-East and Central Queensland. While simulated changes in sediment delivery were modest ( $\pm 8\%$ ) ([Back](#))

## What should grow where? optimising human land use

Grace Robinson \*

Queensland University of Technology

**Author(s):** Grace Robinson

**Time:** Tue 12:20

**Place:** Room 4

Motivated by the complex trade off relationships seen between the sustainable development goals of Zero hunger, Climate Action, and Life on Land we quantified land use allocations impacts on these goals allowing them to be formulated into an optimisation problem. Attempts at understanding the trade-offs these goals present often implement food production as a constraint on the system, despite production often failing to meet demand, as well as prescribing fine-scale regional solutions based on global level assumptions. Instead, we have formulated it as a multi-objective optimisation problem, adding an additional objective of minimising the difference from current land allocations. This will allow the solution space to be more adequately identified allowing practical solutions to be explored that are often overlooked when we are optimising without thought for the realistic level of change possible. We have also established a novel solution method based on non-dominated sorting genetic algorithms to allow us to determine the Pareto-optimal land use allocations over large scale areas. ([Back](#))

## How BaD can it be? Model identifiability for behaviour and disease models

Matt Ryan

CSIRO

**Author(s):** Matt Ryan, David J Price, Roslyn I. Hickson

**Time:** Mon 17:20

**Place:** Room 5

Modelling infectious diseases can give biological insights and inform health policy. But many models ignore a key driver of disease transmission: human behaviour. Since the COVID-19 pandemic, there has been increased interest in building human behaviour into transmission models. This includes studies that aim to infer and interpret behavioural parameters from data. However, few studies have explored how identifiable behavioural parameters are in these contexts. This work looks at understanding model identifiability for behavioural-epidemiological models using a simulation sandbox. We simulated behaviour and infection data from three different ordinary differential equation models. Using Bayesian methods, these models were then fit to the simulated data to understand whether we can recover the generating parameter sets. We explored model identifiability for different data resolution (i.e. daily or weekly), observation times (i.e. pre- or post-peak), and noise levels. The results of this work will inform parameter reliability and help identify potential types of data we should be collecting for future epidemics. ([Back](#))

## Parameter estimation and identifiability analysis of stability and tipping points in lake ecosystems

Amanda Salpadoru \*

Queensland University of Technology

**Author(s):** Dasuni Amanda Salpadoru, Kate Helmstedt, Matthew P. Adams, David J. Warne

**Time:** Wed 10:00

**Place:** Room 4

Ecological regime shifts are a fundamental concept in ecosystem dynamics, describing transitions between alternative stable states that can represent healthier or unhealthier states under the same environmental conditions. Once a tipping point is crossed, reversing the degraded state can be extremely difficult, making early detection and intervention essential for effective ecosystem management. Understanding when and how such shifts occur is important for preventing sudden ecological changes. A key question is whether available standard ecological monitoring data can be used to identify bistability and accurately estimate the tipping points that drive regime shifts between alternative stable states. A well-studied example of such regime shift is the Carpenter model of Lake eutrophication, which leads to bistability between oligotrophic (clear water) and eutrophic (polluted water) states. This model serves as an ideal framework to explore whether lake monitoring data can be used to identify bistability and the parameters that drive regime shifts. To explore the key question, we generate synthetic data under known stability regimes and apply profile likelihood analysis to assess parameter identifiability, along with a profile-wise analysis to determine tipping points and detect system stability. Our analysis highlights that standard monitoring data do not always provide sufficient information to reliably determine whether the ecosystem is in a bistable or monostable regime. Even when a model has identifiable parameters, it does not guarantee that system stability is also identifiable from the data. Similarly, the non-identifiability of parameters does not imply that stability is also non-identifiable. A key finding is that bistability and related tipping points only become practically identifiable when monitoring data very close to the tipping point. This result has broad implications for ecosystem management, as it suggests that bistability and tipping points can only be reliably identified within a narrow observational range near the tipping point. ([Back](#))

### Modelling Initial Calcification in Atherosclerosis

Faith Sawers \*

The University of Adelaide

**Author(s):** Faith Sawers, Ed Green, Yvonne Stokes, Mary Myerscough, Christina Bursill

**Time:** Wed 12:20

**Place:** Room 1 and 2

Atherosclerosis is a precursor to cardiovascular disease that involves the accumulation of fats, cholesterol, and other substances that form a plaque in artery walls. As the disease progresses, calcification begins to occur on this plaque. Biological research suggests that early-stage calcification reflects a vital stage in atherosclerotic plaque development. In this talk, we will present an ODE-model that attempts to capture the initial calcification in an atherosclerotic lesion, and some preliminary results. ([Back](#))

### Decoding Cell Geometry: Insights from Mathematical Modeling Based on Imaging Data

Sungrim Seirin-Lee

Kyoto University

**Author(s):** Sungrim Seirin-Lee

**Time:** Mon 17:20

**Place:** Room 1 and 2

Imagine sitting in a meeting where the shape of the table and your position at it influence how you interact with others. Similarly, in multicellular systems, cells communicate with their neighbors to determine their positions and fates. Thus, spatial and temporal cellular arrangement plays a

crucial role in the developmental processes of multicellular organisms. However, understanding how geometric constraints influence cell fate, movement, and patterning remains a major challenge that is difficult to address through experiments alone. To tackle this problem, we developed a novel mathematical modeling framework called Imaging Data-based Cell Morphology Modeling, which integrates phase-field modeling with actual cell geometry. We applied this framework to analyze dynamic cell arrangement in the 4-cell stage embryo of nematodes. This led to the discovery of a previously unexplored concept, the Extra-embryonic Space (ES), which plays a regulatory role in cell arrangement patterning and had never been considered in biological studies. This finding was further validated through in vivo experiments in *C. elegans* embryos. This study highlights two key points: (1) the future potential of integrating data science into mathematical modeling for biological systems, and (2) the critical importance of incorporating actual cell geometry data to reveal previously hidden mechanisms of life. ([Back](#))

### **Inertial particle focusing in the duct with elliptical centreline**

Siluvai Antony Selvan  
The University of Adelaide

**Author(s):** Siluvai Antony Selvan, Rahil Valani, Brendan Harding, Yvonne Stokes

**Time:** Mon 11:40

**Place:** Room 6

Finite-sized particles suspended in a fluid flowing through a 3D curved duct can focus on attractors, such as stable points and limit cycles, in the two-dimensional cross-section due to inertial focusing effects. Such passive particle focusing finds application in biomedical and other industrial settings, where particles of different sizes can be sorted using purely hydrodynamic effects. For a given particle size, a range of particle attractors is realised in the duct cross-section, depending on the radius of curvature of the duct. In the present study, we consider particles suspended in flow through an elliptical duct with a uniform tall rectangular cross-section to investigate particle separation. Because the radius of curvature varies periodically along the elliptical duct, the particle equilibrium positions in the cross-section also change periodically along its length. In addition to cross-sectional focusing, the elliptical geometry further promotes particle clustering along its length, with the geometric parameters optimised according to the particle size. The clustering behaviour is strongly dependent on particle size, where smaller particles maintain persistent clustering, whereas larger particles exhibit intermittent and less stable clustering patterns. While analysing particle separation in the elliptical duct, we observe non-equilibrium separation, wherein smaller particles– despite exhibiting strong clustering– continue to follow stable limit cycles, whereas larger particles remain focused at the stable nodes located near both walls. These preliminary findings form the basis for examining elliptical-spiral microfluidic devices, which result in enhanced separation that is relevant to biomedical and industrial applications ([Back](#))

### **A Surrogate Model for Efficient Inference of GLUT4 Translocation**

Brock Sherlock\*  
The University of Auckland

**Author(s):** Brock Sherlock, Chris Drovandi, Adelle Coster

**Time:** Wed 10:40

**Place:** Room 1 and 2

Stochastic models are widely used in mathematical biology to capture heterogeneity, uncertainty, and complexity in biological systems. They can reveal mechanistic insights that deterministic

models cannot. However, to extract such insights, models must be fitted to experimental data and simulating stochastic models is often computationally expensive. The computational cost of stochastic models of biological systems can then become prohibitive. Therefore, it is useful to consider efficient inference methods for models requiring expensive simulations.

In previous work, a queuing model of the translocation of the insulin-sensitive glucose transporter was developed to investigate potential insulin-dependent mechanisms in the translocation pathway. In that work, a single potential mechanism of insulin was identified. However, exploring alternative hypotheses and secondary actions of insulin was constrained by simulation costs - single runs in some parameter regions exceeded 12 hours.

To address this, we have investigated the use of surrogate models for efficient parameter inference and hypothesis exploration. Our surrogate model employs feedback terms in a system of differential equations to mimic blocking mechanisms in the queuing network. We perform sensitivity analysis and assess its correspondence to the original model. Results suggest that this surrogate model can support recalibration-based inference. Beyond GLUT4 translocation, this approach has potential applications in other computationally intensive areas of mathematical biology, where stochasticity and high-dimensional parameter spaces become computationally prohibitive. The use of surrogate models with efficient inference algorithms will allow alternative hypotheses to be tested and for the parameter space to be more widely assessed, which is not practical or possible using implementations of stochastic models alone. ([Back](#))

### **Efficient Pricing of American Bond Options under CIR Stochastic Volatility via Coordinate Transformation**

Kajanthan Shiyamasuntharam \*  
University of Wollongong

**Author(s):** Kajanthan Shiyamasuntharam and Xiaoping Lu

**Time:** Wed 09:40

**Place:** Room 3

The aim of this study is to develop an efficient numerical technique for solving multi-dimensional partial differential equations (PDEs) with mixed derivative terms. These PDEs arise in the pricing of American options on bonds under the Cox–Ingersoll–Ross (CIR) interest rate model with stochastic volatility. Analytical solutions to multi-dimensional pricing PDEs are generally not available, if not impossible, necessitating numerical methods. The mixed-derivative term, arising from the correlation between the short rate and volatility, further complicates the implementation of numerical schemes. To address this challenge, we propose an efficient numerical technique using coordinate transformations. The simplified PDE, obtained via two successive coordinate transformations, is then solved using an Alternating Direction Implicit (ADI) finite difference scheme combined with the Thomas algorithm. This technique enhances stability and computational efficiency, and we believe it can be applied to other multi-dimensional PDEs of similar form. Numerical experiments are presented to demonstrate the effectiveness of our approach. ([Back](#))

### **Application of the Approximation Theory in the Field of Magnetic Refrigeration**

Bakhodirzhon Siddikov  
Ferris State University

**Author(s):** Bakhodirzhon Siddikov

**Time:** Wed 11:20

**Place:** Room 4

In 1970's, magnetic refrigeration was identified as a technology that could conceivably provide highly efficient refrigeration above 1 degree Kelvin, perhaps to and above room temperature. Recent developments in the field of magnetic refrigeration have shown that magnetic refrigeration is much more efficient compared to conventional gas compression refrigeration, as well as free of hazardous materials for heat transfer, including chlorofluorocarbons and ammonia. To predict operating characteristics and improve the design of the active magnetic regenerative refrigerator (AMRR) it is desirable to develop mathematical models for AMRR and accurate, stable numerical solvers of the model. One of the difficulties in this work is determining of the physical parameters of the AMRR such as the adiabatic temperature change of gadolinium and the heat capacity of gadolinium. Unfortunately, there exist no known analytical forms of these physical parameters of the AMRR. The only way to have them is to develop highly accurate approximation functions by using experimental measurements of those parameters. In this talk, we will discuss the newly developed mathematical models of AMRR as well as the techniques of developing highly accurate approximation functions for the adiabatic temperature change of gadolinium and the heat capacity of gadolinium. ([Back](#))

### **Peculiar periodicity paths and other patterns in the parameter space of piecewise-linear maps.**

David John Warwick Simpson  
Massey University

**Author(s):** David Simpson

**Time:** Mon 10:00

**Place:** Room 3

The local dynamical behaviour of physical phenomena that switch between different modes of evolution is often governed by a piecewise-linear map. All possible two-piece, piecewise-linear continuous maps on  $\mathbb{R}^2$  can be reduced to a four-parameter family. A long-standing problem is to determine how the parameter space of this family divides into regions according to its dynamics. Numerical explorations show that the regions display various patterns. In this talk I will describe three ways in which these patterns can be understood. Region boundaries where the number of connected components of a chaotic attractor double can be identified through a renormalisation operator, paths of roughly triangular periodicity regions can be approximated from the first derivatives of first return maps, and the bifurcation structure near subsumed homoclinic bifurcations is shown to be driven by a family of one-dimensional discontinuous maps. ([Back](#))

### **Data-informed model reduction for inference and prediction from non-identifiable models**

Matthew Simpson  
Queensland University of Technology

**Author(s):** Matthew Simpson

**Time:** Mon 11:20

**Place:** Room 1 and 2

Many mathematical models in the field of theoretical biology involve challenges relating to parameter identifiability. Non-identifiability implies that different combinations of parameter values lead to indistinguishable solutions of the mathematical model. This means that it is difficult, and sometimes impossible, to explain the mechanistic origin of observations using a non-identifiable mathematical model. A standard approach to deal with structurally non-identifiable models is to

use reparameterisation, which typically focuses on the structure of the mathematical model without accounting for the impact of noisy, finite data. We explore a simple computational approach for model reduction, via likelihood reparameterisation, that can be applied to both structurally non-identifiable and practically non-identifiable problems. We construct simplified, identifiable mathematical models that enable model-based predictions for a range of continuum models based on different classes of commonly-used differential equations. Through a series of computational experiments, we illustrate how to deal with a range of noise models that relate the solution of the mathematical model with noisy observations. A key focus is to illustrate how computationally efficient model-based predictions can be made from reduced models. ([Back](#))

### **Linearized KdV on the line with a metric graph defect**

Dave Smith

The University of Newcastle

**Author(s):** Dave Smith

**Time:** Mon 12:00

**Place:** Room 5

We study the small amplitude linearization of the Korteweg de Vries equation on the line, but with a defect at  $x=0$  represented by a network of finite intervals adjoined at that point, scattering waves. For a representative collection of examples, we obtain explicit contour integral representations of the solution and obtain existence and unicity results for piecewise smooth data. We also discuss extensions to more complex metric graph domains and introduce a serial version of the unified transform method which may be more efficient for such problems. ([Back](#))

### **Epidemiology of Plasmodium knowlesi Malaria in Sabah, Malaysia (2009-2023): case incidence and diagnostic performance**

Sadia Tasnim Sristy \*

AMSI/University of Melbourne

**Author(s):** Sadia Tasnim Sristy, James McCaw, Oliver Eales, Freya Shearer

**Time:** Mon 10:20

**Place:** Room 5

Vector-borne diseases pose a substantial global health burden, with their increasing prevalence and geographical expansion heavily influenced by environmental factors such as climate change, urbanization, and land-use alterations. This study focuses on Plasmodium knowlesi, an emerging zoonotic malaria of public health concern in Southeast Asia, which has a host reservoir in macaques. In Sabah, Malaysia, P. knowlesi malaria has become the most common cause of malaria, despite ongoing efforts to eliminate non-zoonotic Plasmodium species. Plasmodium knowlesi malaria is often misidentified by microscopy as one of the non-zoonotic malarias, such as P. malariae, P. vivax or P. falciparum, and confirmatory testing using molecular tools, such as PCR, is routine.

Here we provide an analysis of malaria case data in Sabah, Malaysia, from 2009 to 2023, building upon a previous study by Cooper and colleagues (2019). Each malaria case record includes results of tests by both microscopy and PCR. We highlight spatial and temporal patterns in case incidence of three Plasmodium species in Malaysia over the 15-year period, and present results from a statistical model investigating the accuracy of first-line microscopy to diagnose P. knowlesi through time. Evaluating the performance of malaria diagnostic methods is vital to understanding the true disease burden and developing more effective strategies for disease management, especially considering the sustained rise in P. knowlesi cases in Malaysia even as other malaria species decline. ([Back](#))

## Modelling the Impact of Bedaquiline-Based Treatment Regimens on Tuberculosis Drug Resistance

Bhavya Srivastava \*

The University of Melbourne

**Author(s):** Bhavya Srivastava

**Time:** Wed 09:40

**Place:** Room 5

Despite being preventable and curable, tuberculosis (TB) remains one of the leading causes of mortality due to infectious diseases worldwide, with the emergence of drug resistance posing a major barrier to elimination. Alternative treatment regimens have been proposed to improve adherence, but their population-level impact on resistance dynamics remains uncertain.

We developed a multi-dimensional deterministic compartmental model, formulated as a system of ordinary differential equations, to investigate TB transmission and the emergence of drug resistance under alternative treatment strategies. The model incorporates parameters associated with disease progression, alternative treatment outcomes, imperfect adherence, and the transmission of multiple drug-sensitive and drug-resistant strains. First, we parameterised the model using TB surveillance data from Georgia. Then, we used the model to compare standard rifampicin-based first-line therapy with a counterfactual strategy in which a shortened Bedaquiline-based regimen is introduced as first-line treatment, allowing treatment switching upon resistance acquisition. The model outcome of interest was transmitted drug resistance. Robustness of conclusions was through scenario-based simulations and global sensitivity analyses.

The model predicts a trade-off between resistance pathways: introducing Bedaquiline as a first-line regimen reduces Rifampicin resistance but may increase Bedaquiline resistance. Outcomes were highly sensitive to patient dropout and the effectiveness of interventions limiting resistant-strain transmission. While model parameters were based on Georgian data, the framework provides general insights into how treatment duration, adherence, and population-based interventions can shape population-level resistance dynamics. ([Back](#))

## Non-preemptive Priority Queues with Distinct Customer Selection Rules

David Stanford

University of Western Ontario

**Author(s):** Na Li, David Stanford, Peter G. Taylor, and Ilze Ziedins

**Time:** Wed 11:20

**Place:** Room 3

In 1957, Kesten and Runnenberg determined the waiting time distributions for customers in a single-server, Poisson arrival queue with multiple priority classes and general, class-dependent service times. It was assumed that when the server was ready to select a customer from a particular priority class, it did so on a first-come, first-served (FCFS) basis among those customers present. We are aware of no work that has considered any other customer selection rule, or, for that matter, differing customer selection rules for different priority classes. Such a focus is the aim of the present work. We show that the same waiting time distribution is obtained as in Kesten & Runnenberg for any class obeying FCFS customer selection, and illustrate how to obtain the waiting time distribution for the case of last-come, first-served (LCFS) customer selection. ([Back](#))

## Modelling and Analysis of Semiconductor Lasers Subject to Fibre Bragg Grating Feedback

Joe Steele\*

The University of Auckland

**Author(s):** Joe Steele, Neil Broderick, and Bernd Krauskopf

**Time:** Mon 11:20

**Place:** Room 3

Semiconductor lasers are compact, efficient light sources widely used in optical communications, and their sensitivity to external feedback makes them rich systems for studying nonlinear dynamics. The Lang-Kobayashi (LK) equations are the standard tool for modelling lasers subject to external feedback from a regular mirror. A key reflective component in optical systems is the fibre Bragg grating (FBG)—a periodic optical fibre refractive index variation—leveraged for its precise spectral control and all-fibre compatibility. When the external feedback comes from an FBG, present modelling requires a computationally expensive convolution term, which provides limited analytical insight into the system's behaviour.

We present a novel modelling approach that approximates FBG feedback by a sum of discrete delay terms. Critically, this avoids the need for numerical convolution while preserving the essential physics. This enables detailed analysis of the laser's mode structure, stability regimes, and bifurcation structure in the spirit of that for the 'classic' LK equations. In this way, our work provides a foundation for deeper theoretical study of semiconductor lasers subject to technologically relevant types of FBG feedback, bridging the gap between numerical simulation and analytical understanding. ([Back](#))

## Modelling chemical signalling on fertilisation of the mammalian cumulus-oocyte complex.

Yvonne Stokes

The University of Adelaide

**Author(s):** Yvonne Stokes, Thomas Miller, Bronwyn Hajek.

**Time:** Mon 15:20

**Place:** Room 4

We describe the first mathematical model of chemical signalling immediately following fertilisation of a mammalian cumulus-oocyte complex (COC), comprising a shell of cumulus nurse cells (the oophorus) around an oocyte.

Through to fertilisation and activation of the oocyte, the cumulus shell is critical to the survival of the oocyte and there is two-way communication/signalling between the two, with hormone (paracrine) signalling from the oocyte regulating the transfer of ions and molecules from the cumulus cells. This communication occurs during COC development in the ovary and continues through ovulation and fertilisation. Sperm entry into the oocyte triggers a  $\text{Ca}^{2+}$  oscillation which induces intra-oocyte protein release and processes that prevent polyspermy and block bidirectional communication between the oocyte and cumulus cells. We develop a mathematical model of this  $\text{Ca}^{2+}$  signalling in the mammalian COC, assumed to be caused by fertilisation of the oocyte.

The model is solved both analytically, using a nonclassical symmetry, and numerically. The model and solutions are a valuable tool for better understanding the processes involved, allowing investigation of a variety of signal types, both individually and in combination. By comparison of modelling results with experiments it is hoped that this important beginning of new life might be better understood. ([Back](#))

### Mode interactions between two length scales

Priya Subramanian  
The University of Auckland

**Author(s):** Priya Subramanian, Pakwan Riyapan, Alastair M. Rucklidge

**Time:** Mon 16:20

**Place:** Room 3

Pattern formation when a single length scale is unstable is the most common pattern forming situation and has been investigated in diverse contexts using many different single length scale models, typically resulting in striped or hexagonal patterns. However, some real-world systems exhibit composite patterns such as grid states, superlattices and quasipatterns, which can be explored using models that have two length scales (one short and the other long) becoming unstable. For now, we concentrate on the case when the length scale ratio is lesser than half, i.e., there is only one-way modal interactions via two long wavevectors adding up to a short wavevector. We explore the different families of amplitude equations that arise, in order to identify the most generic interactions that can occur and will discuss how to use homotopy methods in computational algebraic geometry, to investigate the existence of composite patterns around a codimension-2 bifurcation. ([Back](#))

### From time series to dynamics: a categorical perspective

Tomoharu Suda  
Tokyo University of Science

**Author(s):** Tomoharu Suda

**Time:** Thu 10:20

**Place:** Room 5

There has been growing interest in reconstructing dynamical systems from data. Yet, due to ill-posedness of the problem such as dependence on modeling choices, it remains unclear how to describe data-driven reconstruction within a coherent, structured framework. In this talk, I present a categorical perspective on data and dynamics that clarifies the structure underlying data-driven reconstruction.

We first show that the generation of time-series data by a dynamical system can be naturally modeled as a functor from a category of dynamical systems to a category of time series data. Within this framework, there is a universal reconstruction principle for dynamics taking values in suitably structured categories. Finally, I outline how this categorical viewpoint relates to statistical inference of dynamics. This talk is based on joint work with S. Das (Texas Tech). ([Back](#))

### A Simplified Mathematical Model for Estimating Stenosis Treatment Time in Catheter Procedures

Haruka Suga \*  
Kyushu University

**Author(s):** Haruka Suga, Intan Diyana Munir, Atsushi Tero, Nurul Aini Jaafar, Sharidan Shafie

**Time:** Wed 12:40

**Place:** Room 1 and 2

Vascular stenosis can cause life-threatening diseases such as myocardial infarction and cerebral infarction, and catheter-based treatment is a major therapeutic approach. In this study, we develop a mathematical model in which plaque is removed by medication released from a catheter. While previous studies have focused on single stenosis cases using the Navier–Stokes equations, actual vascular networks may contain multiple stenoses. We fitted a simple equation to flow rate values obtained from previous work and applied it to cases with two stenoses. Our results indicate that, for two stenoses arranged in series, treating the smaller stenosis first shortens the overall treatment time, and that, in most Y-shaped bifurcation cases, treating the bifurcation region first is more effective. ([Back](#))

## Imaging Data-based Model Description Combining Optimal Transport and Phase-field Model

Tsubasa Sukekawa  
Kyoto University

**Author(s):** Tsubasa Sukekawa, Toshiaki Yachimura, Sungrim Seirin-Lee

**Time:** Tue 11:20

**Place:** Room 1 and 2

Capturing geometrical shapes of cells is an essential issue in understanding many biological phenomena [1], and combining the shape information with mathematical models leads to *in silico* experiments reflecting the effect of actual cell shapes. Although advances in experimental techniques have enabled live imaging of cells, the time resolution of the imaging is limited due to various factors, such as phototoxicity. This means that the amount of information on cell geometry necessary to understand a phenomenon may not be available. In this study, we develop mathematical tools to infer intermediate cell shapes from time series data of cell shapes to overcome this limitation. Our method is a combination of optimal transport theory (OT) and a phase-field method. OT is a mathematical theory giving distance and optimal matching between probability distributions, such as point clouds [4]. OT also provides interpolation and velocity fields between probability distributions. Since we can regard cell shapes as point clouds, we can generate intermediate cell shapes by interpolation, and the velocity field represents the cell's deformation and motion. However, the conventional method of OT may generate unnatural deformation, such as cracks. This property may be due to the fact that interpolation by optimal transport theory does not reflect the physical properties of the cells. To improve this, we combine the velocity field obtained by OT with a phase-field model. Our new method successfully regenerated cell dynamics with smooth and natural cell shapes using live imaging data sets of *C. elegans* cells and HL-60 cells. Finally, we propose a new biochemical modeling method, which combines the realistic cell shapes with previous computational methods [3, 4]. Our research will open new avenues for mathematical modeling approaches to pattern formation phenomena, including cell dynamics based on live imaging data of cells.

## References

- [1] S. Seirin-Lee, K. Yamamoto, and A. Kimura, The extra-embryonic space and the local contour are crucial geometric constraints regulating cell arrangement, *Development*, 149 (9): dev200401, 2022.
- [2] G. Peyré, and M. Cuturi, Computational optimal transport: With applications to data science, *Foundations and Trends® in Machine Learning*, 11(5-6), 355-607, 2019.

- [3] J. Kockelkoren, H. Levine, and W.-J. Rappel, Computational approach for modeling intra- and extracellular dynamics, *Physical Review E*, 68 (2), 037702, 2003.
- [4] S. Seirin-Lee, The role of cytoplasmic MEX-5/6 polarity in asymmetric cell division, *Bulletin of Mathematical Biology*, 83(4), 29, 2021.

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### **Flow in a rotating film: how far can one go without DNS?**

Sergey A. Suslov  
Swinburne University of Technology

**Author(s):** Sergey A. Suslov, Valantis Thomopoulos and Andrey Pototsky

**Time:** Mon 16:00

**Place:** Room 6

Remember blowing soap bubbles as a child and how they could sit on a rim of an empty can? Now imagine that a soap film is stretched between two cans of different diameters, one inside the other, both put on top of a magnet and connected to a battery. The film between the two rims will rotate and multiple vortex patterns may form that are naturally two-dimensional, thus quite exotic in our three-dimensional world. Such two-dimensional patterns are of significant interest representing a physical realisation of frequently used analytical paradigm. The observed patterns can nonlinearly interact or replace each other depending on how quickly the film rotates. To model that, one would normally rely on direct numerical simulations (DNS), but they are very time-consuming. We will discuss whether one can accurately predict what is going to happen with the observable vortices without DNS, and if so, how far parametrically from a codimension point, where multiple vortex modes first appear this can be done. [\(Back\)](#)

### **Birds, Fish and Finding Nice Shapes**

Winston Sweatman  
Massey University

**Author(s):** Winston Sweatman

**Time:** Thu 09:40

**Place:** Room 5

During the the six years 2019-2024, I had the pleasure of working with a team of statistical ecologists to produce new models of species' responses to their environment. One aspect was producing suitable curves for fitting distributions. I discuss these and the overall project. [\(Back\)](#)

### **Thin-film modelling and parameter optimisation for biofilms**

Alex Tam  
Adelaide University

**Author(s):** Alex Tam; Daniel Netherwood; Ben Binder; Ed Green

**Time:** Tue 11:40

**Place:** Room 1 and 2

Yeast colonies exhibit a wide range of patterns and growth modes, making them a fruitful source of mathematical modelling problems. Our group aims to better understand yeast growth using agent-based, reaction–diffusion, and continuum mechanical models, and collaborates with experimental yeast biologists based in Australia and the UK. Biofilms are a form of growth characterised by communities of cells residing within a self-produced protective viscous matrix. They cause an estimated 80% of all microbial infections and are difficult to remove, giving them particular biomedical importance.

I will discuss our recent work that applies an extensional-flow thin-film model to model how agar density affects biofilm growth in lab experiments. The mathematical model contains 5 unknown parameters, requiring multiple experimental measurements (biofilm size, shape, and composition) and numerical optimisation to estimate parameters effectively. Parameter optimisation reveals that higher density agar increases biofilm–substratum adhesion strength, which favours vertical over horizontal expansion. ([Back](#))

### **Strategic Customer Behaviour in an M/M/1 Feedback Queue**

Peter Gerrard Taylor  
The University of Melbourne

**Author(s):** Peter Taylor and Jiesen Wang

**Time:** Mon 15:20

**Place:** Room 6

We consider an M/M/1 feedback queue in which service attempts may fail, requiring the customer to rejoin the queue. Arriving customers act strategically, deciding whether to join the queue based on a threshold strategy that depends on the number of customers present. Their decisions balance the expected service reward against the costs associated with waiting, while accounting for the behavior of others.

This model was first analyzed by Fackrell, Taylor and Wang (2021), who assumed that waiting costs were a linear function of the time in the system. They showed that increasing the reward for successful service or allowing renegeing can paradoxically make all customers worse off.

In this paper, we adopt a different setting in which waiting does not incur direct costs, but service rewards are subject to discounting over time. We show that under this assumption, paradoxical effects can still arise. Furthermore, we develop a numerical method to recover the sojourn time distribution under a threshold strategy and demonstrate how this can be used to derive equilibrium strategies under other payoff metrics. ([Back](#))

### **MINZ, protein power drinks and traffic flow**

Steve Taylor  
The University of Auckland

**Author(s):** Steve Taylor, Alastair Jamieson-Lane, Nicholas Lam, Winston L. Sweatman, Graeme Gillies and Lisa Thomasen

**Time:** Thu 10:40

**Place:** Room 3

Fonterra has developed a method to create fortified drinks by creating suspensions of the nutrients in highly viscous liquids. They presented a problem to the 2025 MINZ “Mathematics-in-Industry New Zealand” study group to see if participants could find a mathematical way of improving their processes. Specifically, the task involved analysing the sedimentation of the nutrients that

occurs over a time scale of several months to see if we could reduce the amount of laboratory measurements and storage of samples of these products.

I'll discuss the mathematical modelling that took place and its connection to a well-known mathematical model for traffic flow. ([Back](#))

### **A decentralized algorithm with application to min-max problems**

Liam Timms \*

The University of Melbourne

**Author(s):** Matthew K Tam, Liam Timms, Lele Zhang

**Time:** Tue 12:20

**Place:** Room 3

Consider a population of agents coordinating to find a saddle point of a finite sum of convex-concave functions, where some operators are differentiable and the rest are potentially discontinuous. We propose a forward-backward-type algorithm for this problem suitable for decentralised implementation. In each iteration, agents evaluate a gradient and a proximal operator, and then communicate with neighbouring agents. The agents choose their step sizes independently using only local information, and the step size upper bound has no dependence on the communication graph. We demonstrate the advantages of these properties with numerical results for zero-sum games. ([Back](#))

### **Data Driven Assessment of Climate Change Impacts on Water Quality Index in Tukituki River**

Parul Tiwari

Auckland University of Technology

**Author(s):** Parul Tiwari

**Time:** Tue 09:40

**Place:** Room 4

Water quality is increasingly exposed to climate-driven changes in temperature, rainfall, and hydrological regimes, yet quantitative frameworks that link daily climate variability to composite water quality indices remain scarce. This study develops a two-stage modelling approach that first computes a daily Water Quality Index (WQI) from observed physicochemical and nutrient parameters and then predicts WQI as a function of daily climate drivers using statistical and machine-learning models. WQI is derived using a weighted index formulation, aggregating key water quality variables into a single score that reflects suitability for ecosystem and human uses. The climate – WQI relationship is then modelled using non-linear regression. Historical data are used to train and validate the models, with time-aware cross-validation and performance metrics focused on both overall error and the ability to reproduce low-quality episodes. This framework provides an efficient and interpretable tool for anticipating climate change impacts on water quality and supporting the design of adaptation and management strategies. ([Back](#))

### **The role of antibody-mediated immunity in shaping the seasonality of respiratory viruses**

Ruarai Tobin \*

The University of Melbourne

**Author(s):** Ruarai Tobin, James McCaw, Freya Shearer  
**Time:** Mon 10:00  
**Place:** Room 5

In temperate regions, respiratory virus epidemics recur on a yearly basis, primarily during the winter season. This is believed to be the result of seasonal forcing, where the rate at which the virus may be transmitted varies cyclically across the course of each year. In this talk, we examine how the dynamics of antibody-mediated immunity can shape the seasonal recurrence of epidemics, developing a susceptible-infectious-susceptible (SIS) immuno-epidemiological model of respiratory virus transmission. Complex interactions are identified between the strength of seasonal forcing and the antibody decay rate, yielding diverse long-term dynamics including multi-year periodicity, quasiperiodicity and chaos. ([Back](#))

### **Modelling and Optimisation of Melt Pool Geometry in Metal Additive Manufacturing**

Nataliya Togobytska  
HTW Berlin - University of Applied Sciences

**Author(s):** Nataliya Togobytska, Rostyslav Podolskyi and Ganna Kononenko  
**Time:** Wed 12:00  
**Place:** Room 3

Additive manufacturing, particularly Laser Powder Bed Fusion (LPBF), is a promising technology for producing high-performance metal parts with complex geometries. Accurate prediction and optimisation of melt pool geometry are essential for minimising defects and ensuring consistent part quality. In this work, we present a physics-based Eagar–Tsai model to simulate melt pool behaviour under varying process conditions. Additionally, three machine learning models are developed using experimental data from LPBF trials using 316L stainless steel. These models capture nonlinear relationships between key process parameters, namely laser power and scan speed, and the resulting melt pool depth and width, providing a foundation for improved control of melt pool formation and process optimisation. A reinforcement learning (Q-learning) framework is also applied to identify laser parameter combinations that achieve the desired melt pool characteristics. ([Back](#))

### **Mathematical Modelling of bilayer cathodes that enable fast charging of lithium-ion batteries**

Eloise Tredenick  
University of Canberra

**Author(s):** Eloise Tredenick  
**Time:** Mon 12:20  
**Place:** Room 4

Heterogeneities in lithium ion batteries can be significant factors in electrode under utilisation and degradation while charging. Bilayer electrodes have been proposed as a convenient and scalable way to homogenise the electrode response and reduce inefficiencies. We introduce the design of a bilayer cathode for Li-ion batteries composed of separate layers of lithium nickel manganese cobalt oxide (NMC622) and lithium iron phosphate (LFP), which is optimised using our new multilayer Doyle-Fuller-Newman (M-DFN) model. Through a sensitivity analysis, it was found that changes to the carbon binder domain, electrolyte volume fraction, and tortuosity provided the greatest control for improving Li-ion charge mobility. The optimised bilayer design was able to charge at 3C between 0-90([Back](#))

### Curved vegetation stripes on a curved terrain

Justin Tzou  
Macquarie University

**Author(s):** Justin Tzou

**Time:** Mon 16:00

**Place:** Room 4

Striped vegetation patterns can form in semi-arid climates that cannot support full vegetation coverage. It has been well-documented that these stripes typically form on hillsides, orthogonal to the hill gradient. It has also been observed that these stripes curve when the underlying terrain is curved. By analyzing a simple PDE model of a vegetation-soil water system, we derive an expression for the stripe curvature in terms of the terrain topography, and give an intuitive explanation as to why the stripes curve the way they do. ([Back](#))

### Flow dynamics of a viscous fluid above granular material on a slope

Fiaz Ur Rehman\*  
Monash University

**Author(s):** Fiaz Ur Rehman, Edward M. Hinton, Anja C. Slim

**Time:** Mon 12:20

**Place:** Room 6

Gravity-driven flows involving both viscous fluid and granular material occur in settings ranging from debris flow and subglacial till deformation to mineral mining and industrial slurry transport. In this work, we investigate the evolution of a two-layer gravity current in which a Newtonian fluid overrides a yield-stress granular material, generating complex interaction between viscous spreading and granular yielding on an inclined plane. We develop the mathematical model to describe the flow. The granular layer obeys  $\mu(I)$ -rheology. We considered different initial shapes of the viscous deposit. At early times, fast transport of granular material takes place beneath the viscous deposit. At late times, we observe different flow regimes that result in trapping of the viscous liquid. ([Back](#))

### Unusual nonlocal calculus assists cancer cell growth treatments

Graeme Wake  
Massey University

**Author(s):** Graeme Wake

**Time:** Mon 15:00

**Place:** Room 1 and 2

Modelling of cell-growth in growing and proliferating cancer-cell cohorts gives rise to an unusual functional differential equation of an advanced type (not in time) which showed stability in time by retaining the shape of the steady size-distribution of cells (SSDs). The history, development, and use of this problem will be described in this presentation. The team started in 1989, working briefly with plant root cells. The need for more comprehensive data sets so as to audit the model, shifted the focus to cancer cells, where DNA content became a proxy for size which is measured by a fluorescent beam process. The model describing the temporal evolution of SSDs, greatly reduces the amount of experimental work required to underpin decision processes of testing the value of proposed new drug treatments. The development is ongoing, though delayed by the

shortage of funding. The model is simple enough to require many fewer parameters obtained by less experiments and delays, and therefore concentrated on just the Mitosis phase of cell division simultaneously growing and dying. The current team includes Associate-Professor Bruce van-Brunt (Massey University NZ); Emeritus Professor Bruce Baguley, (Cancer Research Group, University of Auckland, NZ); Dr Steve Taylor, (University of Auckland, NZ); Associate-Professor Ali Zaidi (Lahore University of Management Sciences, Pakistan); and the author. This work is supported in part by the Department of Electrical and Computer Engineering, University of Canterbury, and partly supported the author's contributions by Associate Professor Chris Hann of that Department. ([Back](#))

### **A viscoplastic deposit on a vibrating plate**

Matthew Walker \*

The University of Melbourne

**Author(s):** Matthew J. Walker, John E. Sader, Douglas R. Brumley, Edward M. Hinton

**Time:** Mon 11:20

**Place:** Room 6

Viscoplastic fluids are non-Newtonian fluids that do not flow until the magnitude of the internal stress exceed a threshold 'yield stress'. Motivated by recent experimental work exploring the oscillation of drops of molten chocolate and Carbopol – two viscoplastic materials – we study a thin, axisymmetric deposit of viscoplastic fluid as it slumps atop a plate exhibiting vertical oscillations. An asymptotic model is derived for relatively low oscillation frequencies, and its solutions are compared with the experimental results. These flows become arrested asymptotically and approach a static, symmetric shape for which an exact expression is reported. In the regime where downward acceleration overcomes the yield stress, surface tension must be introduced into the model to combat the emergent free-surface instability. This instability is analysed and compared to the Newtonian case. ([Back](#))

### **Canine Ehrlichiosis in Northern Australia: A Sensitivity and Elasticity Analysis of $R_0$**

Weisheng Wang \*

RMIT University

**Author(s):** Weisheng Wang, Simon Johnstone-Robertson, Stephen A. Davis

**Time:** Wed 10:20

**Place:** Room 5

Canine ehrlichiosis is a potentially fatal tick-borne bacterial disease of domestic dogs caused by *Ehrlichia canis* and transmitted by the brown dog tick, *Rhipicephalus linnaei*. *E. canis* occurs throughout the United States, South America, Asia, and Africa, and recently emerged among domestic dogs in the Kimberly region of West Australia in May 2020. The pathogen has spread across the northern regions of Australia, prompting the development of awareness campaigns and bringing new attention to human-mediated dog movement. We constructed a next generation matrix to estimate the basic reproduction number,  $R_0$ , for *E. canis*. We find that there is considerable uncertainty in  $R_0$  reflected in a lack of field studies on the abundance and life history of the immature stages of the primary vector. We calculated an average  $R_0$  of 1.24 with 95([Back](#))

## Efficient simulation and inference of non-Markovian stochastic biochemical reaction networks

David James Warne

Queensland University of Technology

**Author(s):** Thomas P. Steele and David J. Warne

**Time:** Mon 12:00

**Place:** Room 1 and 2

Stochastic models of biochemical reaction networks are widely used to capture intrinsic noise in cellular systems. The typical formulation of these models are based on Markov processes for which there is extensive research on efficient simulation and inference. However, there are biological processes, such as gene transcription and translation, that introduce history dependent dynamics requiring non-Markovian processes to accurately capture the stochastic dynamics of the system. This greater realism comes with additional computational challenges for simulation and inference. In this work, we develop efficient non-Markovian simulation algorithms for well-mixed stochastic biochemical reaction networks that include state and time-dependent delays. Our methods generalize the next reaction method and  $\tau$ -leaping method to support arbitrary inter-event time distributions while preserving computational scalability. We also introduce a coupling scheme to generate exact non-Markovian sample paths that are correlated to an approximate non-Markovian  $\tau$ -leaping sample path. This enables substantial computational gains for Bayesian inference of model parameters through multifidelity simulation-based inference schemes. We demonstrate the effectiveness of our approach on a gene regulation model with delayed auto-inhibition, showing substantial gains in both simulation accuracy and inference efficiency of two orders of magnitude. These results extend the practical applicability of non-Markovian models in systems biology and beyond. ([Back](#))

## Next-generation computational design with unfitted finite elements and automatic shape differentiation

Zachary James Wegert

Queensland University of Technology

**Author(s):** Zachary J. Wegert, Jordi Manyer, Connor Mallon, Santiago Badia, Vivien J. Challis

**Time:** Thu 09:40

**Place:** Room 4

Shape and topology optimisation facilitate the optimisation of material layouts to maximise design performance subject to physics constraints in the form of Partial Differential Equations (PDEs). These computational techniques are key technologies for a wide range of industrial applications such as advanced additive manufacturing.

Level-set topology optimisation parameterises a design domain by the sign of a level-set function and updates the shape of the domain by solving a transport equation. Typically, the underlying PDEs are solved over a domain that is immersed in a static computational domain by smoothing the boundary. This allows integration to be relaxed over the whole computational domain. While this is suitable for many problems, it can lead to undesirable computational artefacts, particularly for multi-physics such as fluid-structure interaction. In addition, differentiation in a smoothed-boundary regime is unable to fully capture the derivative of a functional under a perturbation of the boundary. Unfitted finite element methods, which enable integration over a sharp boundary without introducing additional degrees of freedom, improve model fidelity and are a promising way to address these problems.

In the first part of the talk, I will introduce shape calculus and level set-based topology optimisation. Following this, I will discuss recent advances using unfitted finite elements and automatic shape differentiation. ([Back](#))

### **Water wave scattering by a rectangular anisotropic elastic plate**

Ben Wilks  
University of South Australia

**Author(s):** Ben Wilks, Michael H. Meylan, Zachary Wegert, Vivien Challis, Ngamta Thamwattana

**Time:** Tue 10:00

**Place:** Room 5

Piezoelectric plates, which become electrically polarised in response to bending, have recently been proposed for the conversion of water wave energy into electrical energy. However, many piezoelectric materials (e.g. Polyvinylidene Fluoride) are anisotropic, which makes them challenging to model in three dimensions. This talk considers the simpler problem of water wave scattering by an anisotropic elastic plate, i.e., the piezoelectric effect is ignored but the anisotropy is retained. The problem is solved using a dry modes expansion. In turn, the necessary diffraction and radiation problems are solved by formulating a boundary integral equation and solving numerically using a constant panel method. Results are presented to highlight the resonant responses of the plate under different forcing scenarios. ([Back](#))

### **Modelling the growing outer membrane of Gram-negative bacteria**

Thomas Williams  
The University of Melbourne

**Author(s):** Thomas Williams, Trevor Lithgow, KJ Goh, James Osborne, Jennifer Flegg

**Time:** Thu 09:40

**Place:** Room 1 and 2

Gram-negative bacteria are organisms of great medical significance, especially in the context of growing antimicrobial resistance. The double membrane of these bacteria is one of the principal obstacles in effective antibiotic delivery. Much remains unknown about how these membranes are structured, how they grow, and how this is regulated. Mathematical modelling can provide insights into these questions, as well as predict how Gram-negative membranes behave under perturbations like gene mutation or treatment with antibiotics. However, existing molecular dynamics models are too complex to simulate membrane dynamics beyond the microsecond time scale. A new, coarser-grained approach is needed to study these systems on the seconds-to-minutes time scale of cell growth. In this work, we implement such a model and show the emergence of clear structural features of the growing membrane. Simulations hint at previously unclear roles for membrane proteins and lipopolysaccharides in regulating membrane growth. ([Back](#))

### **A Novel Secondary Therapeutic Strategy Combined with Antihistamines Based on Morphology-Defined Endotypes of Chronic Spontaneous Urticaria**

Ying Xie  
Kyoto University

**Author(s):** Ying Xie, Ryo Saito, Daiki Matsubara, Shunsuke Takahagi, Michihiro Hide, Takahiro Hiraga, Sungrim Seirin-Lee

**Time:** Mon 15:20

**Place:** Room 1 and 2

Chronic spontaneous urticaria (CSU) is an immune-mediated skin disease characterized by red, itchy eruptions of various shapes, known as wheals. Second-generation H1 antihistamines are a mainstay of treatment, but treatment responses vary widely among patients, with approximately 30% remaining symptomatic despite conventional therapy. On the other hand, our previous studies have identified five distinct types of wheal morphology, which are associated with the activation loop of basophils in the endothelium and the histamine-release positive feedback loop of mast cells in dermis. Our results suggest that CSU can be classified into five endotypes, which corresponds well to clinical observations, and new, more effective targeted therapies could be developed based on these endotypes. To address this, we studied the effectiveness of antihistamines across these endotypes. We first evaluated the severity of CSU and efficacy of antihistamines *in silico* using three key measures: wheal area, itching severity, and wheal expansion dynamics, across the five identified endotypes. Our results showed that even though we assumed the same intensity of H1 histamine receptor suppression, the overall effectiveness to reduce the symptom varied depending on the endotypes. Furthermore, we found a key pathological network associated with antihistamine efficacy, which enables the proposal of new targeted immune drugs for the treatment of CSU. Our study demonstrates that mathematical and morphological endotyping of CSU can uncover hidden therapeutic determinants and pave the way for next-generation targeting critical components in the mechanism of individual patients. ([Back](#))

### Resolving two-body hydrodynamic interactions between microswimmers

Xinyi Yang\*

The University of Melbourne

**Author(s):** Xinyi Yang, Hailong Guo, Jesse Collis, Takuji Ishikawa, Douglas Brumley

**Time:** Wed 12:00

**Place:** Room 5

The squirmer model is a canonical model for spherical microswimmers (e.g., ciliated microorganisms and Janus particles) in Stokes flow, where propulsion is driven by a surface slip velocity. Due to its simplicity and versatility, the squirmer model is a popular tool for modelling the collective dynamics of microswimmers. While the flow field of a single squirmer in an infinite fluid domain is fully resolved, our knowledge on the hydrodynamic interactions between a pair of squirmers at all separations is still incomplete. This will become important in dynamic simulations of suspensions of microswimmers, such as Stokesian Dynamics. In this work, we use a boundary collocation method to resolve the hydrodynamics of a pair of squirmers with high efficiency and accuracy. Ultimately, this method permits investigation of systems involving non-spherical microswimmers at a range of length scales, from single particle to collective dynamics. ([Back](#))

### Modelling trophoblast bilayer turnover: an agent-based modelling approach

Liuhaoyu\*

The University of Auckland

**Author(s):** Liuhaoyu (Bruce) Yu, Tet Chuan Lee, Jo James, Alys Clark

**Time:** Wed 11:40

**Place:** Room 6

The villous tree structure of the placenta is critical for maternal-fetal exchange. Each villus is covered by a bilayer of epithelial cells consisting of an outer layer of one large multinucleated cell called syncytiotrophoblast, and an underlying layer of proliferative cytotrophoblasts. This

bilayer has unique dynamic changes during pregnancy: the cytotrophoblasts fuse into the syncytiotrophoblast to facilitate its expansion, and aged regions of the syncytiotrophoblast are shed into the maternal circulation. This turnover process is critical for placental health and exchange function.

We developed a vertex-based model of villous bilayer development. Our model describes the movement and mechanical interactions of cells within a two-dimensional bilayer with a fixed-end boundary condition. We represent syncytiotrophoblast and cytotrophoblast each with distinct mechanical properties, and evolve the bilayer using rules directly corresponding to key cellular processes that regulate turnover of the trophoblast bilayer: division of the cytotrophoblasts, fusion of the cytotrophoblasts into the syncytiotrophoblast that expands the syncytiotrophoblast, and the extrusion of the aged syncytiotrophoblast regions. We have used this model to quantify how syncytiotrophoblast thickness, curvature, and stability vary under various proliferation, fusion, and extrusion settings. These analyses reveal how cellular behaviours involved in trophoblast turnover contribute to bilayer changes seen in pathology (i.e. altered syncytiotrophoblast thickness, shedding, budding of new villi). ([Back](#))

### **Gender representation at mathematics conferences in Australia: all a matter of perception?**

Adriana Zanca

The University of Melbourne

**Author(s):** Adriana Zanca, Lucinda Harrison, Isobel Abell, Punya Alahakoon, Jennifer Flegg

**Time:** Tue 10:40

**Place:** Room 3

From high school level through to Level E academics, there is a loss of people who identify as female in the mathematical and statistical sciences in Australia. (There is scarce data on people who identify as nonbinary and/or have a transgender history, experience or identity.) These dropout rates come at the detriment of individuals, the community, and the advancement of the field. In the mathematical and statistical academic fields, conferences provide an opportunity to engage with academics outside of a researcher's geographic locale. Conference participants are a (biased) subset of the academic community at a moment in time. This subset of people can influence the perceptions of gender representation in the field among conference attendees. Therefore, the actual and perceived gender representations at conferences is one aspect informing the community's approach to gender representation.

Since 2024, we have been collecting data on actual and perceived representations of gender at mathematical conference held in Australia, including the annual ANZIAM conference in 2025 and 2026. In this talk we will present the results of our findings and answer the question: do our perceptions of gender representation at mathematics conferences match reality? ([Back](#))

## 9 Registrants

Isobel Abell	The University of Melbourne
Matthew Adams	Queensland University of Technology
Ofri Adiv	The University of Auckland
Fahad Saif Al Saadi	Military Technological College
Sami Al-Izzi	UNSW Sydney
Anuradha Dhananjanie Priyadarshana Alankara Dewage	Queensland University of Technology
Nawal Alsubaie	Victoria University
Tharindi Thathsarani Amarathunge Achchige	Adelaide University
Caitlin Anchor	University of Adelaide
Christopher Angstmann	University of New South Wales
Md Nurul Anwar	The University of Melbourne
Zayed Asiri	Flinders University
Fadi Awawdeh	The Hashemite University
Andrew Axelsen	University of Tasmania
Boris Baeumer	University of Otago
Christopher Baker	The University of Melbourne
Indu Bala	The University of Adelaide
Rowena Ball	The Australian National University
Andrew Bassom	University of Tasmania
Luke Bennetts	The University of Melbourne
Matthew Berry	University of New South Wales
Edward Bissaker	The University of Newcastle
Chantelle Blachut	University of New South Wales Canberra
Liam Blake	Adelaide University
Samuel Bolduc-St-Aubin	The University of Auckland
Tim Bourke	The Australian National University
Philipp Braun	Australian National University
Philip Broadbridge	La Trobe University
Alexander Browning	The University of Melbourne
Douglas Brumley	The University of Melbourne
Pascal R. Buenzli	Queensland University of Technology
Thi Hoa Bui	Curtin University
Judith Bunder	Adelaide University
Bethany Caldwell	University of New South Wales
Pengxing Cao	The University of Melbourne
David Ceddia	The University of Melbourne

<a href="#">Pierluigi Cesana</a>	Kyushu University
Vivien Challis	Queensland University of Technology
Jiawen Chen	Swinburne University of Technology
<a href="#">Jinghao Chen</a>	Kyoto University
<a href="#">Rebecca Chisholm</a>	La Trobe University
<a href="#">Alys Rachel Clark</a>	The University of Auckland
Simon Clarke	Monash University
<a href="#">Robert Cope</a>	University of New England
<a href="#">Robert Cope</a>	University of New England
Adelle Coster	University of New South Wales
<a href="#">Jessica Crawshaw</a>	Queensland University of Technology
<a href="#">Richard Creswell</a>	The University of Melbourne
Barry Francis William Croke	Australian National University
<a href="#">Michael Dallaston</a>	Queensland University of Technology
<a href="#">Stephen Davis</a>	RMIT University
<a href="#">Siwen Deng</a>	Kyoto University
Neil Dizon	UNSW Sydney
<a href="#">Lucy Dowdell</a>	Queensland University of Technology
<a href="#">Celia Dowling</a>	The University of Melbourne
Kevin Downard	UNSW Sydney
<a href="#">Edgar Duéñez-Guzmán</a>	Gilbran AI
<a href="#">Oliver Eales</a>	The University of Melbourne
<a href="#">Chathurika Srimali Gunasekara Ekanayaka Mudiyansele</a>	Curtin University
<a href="#">Maud El-Hachem</a>	CSIRO
Darren Engwirda	CSIRO
<a href="#">Edoardo Fabbrini</a>	Kyoto University
Mark Fackrell	The University of Melbourne
<a href="#">Muhammad Asim Farooq</a>	The University of Sydney
<a href="#">Kaniz Fatema</a>	RMIT University
<a href="#">Jennifer Flegg</a>	The University of Melbourne
Nicolas Flores Castillo	BHP Billiton
<a href="#">Brendan Florio</a>	Murdoch University
<a href="#">Elijah Foo</a>	The University of Melbourne
<a href="#">Larry Forbes</a>	University of Tasmania
<a href="#">Joshua Forrest</a>	The University of Melbourne
STEVEN FRASER	University of New England
<a href="#">Gary Froyland</a>	UNSW Sydney
<a href="#">Ryo Fujie</a>	Kyushu University
Agah D. Garnadi Garnadi	Retired
<a href="#">Jacob Gentner</a>	Queensland University of Technology
Domenic Paul Joe Germano	The University of Melbourne
<a href="#">Liam Gibson</a>	University of Canterbury
<a href="#">Dhruv Goel</a>	University of Wollongong
<a href="#">Cecilia González-Tokman</a>	The University of Queensland
<a href="#">Patrick Grant</a>	The University of Melbourne
<a href="#">Catheryn Gray</a>	University of New South Wales
<a href="#">Michael Groom</a>	CSIRO
<a href="#">Hritika Gupta</a>	University of Wollongong
Bronwyn Hajek	Adelaide University
<a href="#">Ashley Hanson</a>	The University of Melbourne

Tianxiao Hao	The Kids Research Institute Australia
Elizabeth Harris	The University of Newcastle
Catherine Hassell Sweatman	Auckland University of Technology
Yoshimichi Hayashi	Kyushu University
Andreas Heinecke	The University of Newcastle
Peter Heiss Synak	Australian National University
Teresa Heiss-Synak	The Australian National University
Roslyn Hickson	CSIRO and James Cook University
Edward Hinton	The University of Melbourne
Alexandra Hogan	UNSW Sydney
Matthew Holden	The University of Queensland
Jordan Holdorf	Griffith University
Kailas Honasoge	Delft University of Technology
Yilei Huang	The University of Melbourne
Yingkun (Queenie) Huang	University of New South Wales
Hilary Hunt	QUT
Elizabeth Ivory	The University of Melbourne
Tristen Jackson	QUT
Elizabeth Jagerma	Adelaide University
Javane Javaherchian	The University of Melbourne
Thisaakhya Jayakody	The University of Melbourne
Sam Jelbart	Adelaide University
David Jenkins	The University of Newcastle
Heather Jenkins	Bioeconomy Science Institute
Adrienne Jenner	Queensland University of Technology
Stuart Johnston	The University of Melbourne
Simon Johnstone-Robertson	RMIT University
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Zlatko Jovanoski	University of New South Wales Canberra
Matthias Kabel	Fraunhofer ITWM
Taiga Kadowaki	Kyushu University
Kenji Kajiwara	Kyushu University
Salam Kamoona	Swinburne University of Technology
NEDA KHODABAKHSH JONIANI	The University of Sydney
Thomas Kimpson	The University of Melbourne
Maria Kleshnina	QUT
John H Knight	Australian National University
Lyndon Koen	The University of Adelaide
Kazuki Koga	Institute of Science Tokyo
Komal Komal	Swinburne University of Technology
Maame Akua Korsah	The University of Melbourne
Noa Kraitzman	Macquarie University
Bernd Krauskopf	The University of Auckland
Ankit Kumar	Birla Institute of Technology and Science, Pilani
Alexander Labovsky	Michigan Technological University
Kerry Landman	The University of Melbourne
Tomas Lasic Latimer	The University of Sydney
Thao P. Le	The University of Melbourne
Paul Charles Leopardi	Australian National University
Tiffany Leung	UNSW Sydney

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Caitriona Lightbody	The University of Adelaide
Vincent Lomas	University of Canterbury
Daniel Longmuir	RMIT University
Christopher Lustri	The University of Sydney
Michael Lydeamore	Monash University
Matthew Mack	University of South Australia
Cooper Maher	RMIT University
Mohd Mahayaudin Mansor	UNIVERSITI TEKNOLOGI MARA
Kaname Matsue	Kyushu University
James McCaw	The University of Melbourne
Scott McCue	Queensland University of Technology
Hannah McGregor	The University of Auckland
Timothy McLennan-Smith	Defence Science and Technology Group
Mike Meylan	The University of Newcastle
Claire Miller	The University of Auckland
Joel Miller	La Trobe University
Elise Mills	Queensland University of Technology
Fumito Mori	Kyushu University
Liam Morrow	Australian National University
Ryan Murphy	Adelaide University
Mary Myerscough	The University of Sydney
Daniel J Netherwood	The University of Adelaide
Hanh Nguyen Nguyen	Swinburne University of Technology
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Terence O'Kane	CSIRO
Dietmar Oelz	The University of Queensland
Cecilia Olivesi	The University of Auckland
Louise Marie Olsen-Kettle	Swinburne University of Technology
James Mark Osborne	The University of Melbourne
Hinke Osinga	The University of Auckland
Idowu Ademola OSINUGA	Federal University of Agriculture, Abeokuta
Lata Paea	The University of Auckland
Michael Pan	UNSW Sydney
Davide Papapicco	The University of Auckland
Haewoon Park	The University of Sydney
Luz Pascal	Queensland University of Technology
Aidan Patterson	University of South Australia
Michael Plank	University of Canterbury
David Plenty	University of Wollongong
Olle Ponten	The University of Melbourne
Pantea Pooladvand	The University of Sydney
Andrey Pototsky	Swinburne University of Technology
Rudi Prihandoko	The Australian National University
Courtney Rose Quinn	University of Tasmania
Kavita Ramanan	Brown University
Llewyn Randall	Griffith University
Melanie Roberts	Australian Rivers Institute, Griffith University
Tony Roberts	Queensland University of Technology
Vanessa Robins	Australian National University

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Grace Robinson	Queensland University of Technology
Pieter Roffelsen	The University of Sydney
Matt Ryan	CSIRO
Nina Rynne	Australian Rivers Institute, Griffith University
Amanda Salpadoru	Queensland University of Technology
Faith Sawers	The University of Adelaide
Sungrim Seirin-Lee	Kyoto University
Sungrim Seirin-Lee	Kyoto University
Siluvai Antony Selvan	The University of Adelaide
Jason Sharples	University of New South Wales
Jordan Shaw-Carmody	The University of Newcastle
Freya Shearer	The University of Melbourne
Brock Sherlock	The University of Auckland
Kajanthan Shiyamasuntharam	University of Wollongong
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Mary Silber	University of Chicago
David John Warwick Simpson	Massey University
Matthew Simpson	Queensland University of Technology
Dave Smith	The University of Newcastle
Sandy Spiers	Curtin University
Sadia Tasnim Sristy	AMSI/University of Melbourne
Bhavya Srivastava	The University of Melbourne
Eva Stadler	UNSW Sydney
David Stanford	University of Western Ontario
Joe Steele	The University of Auckland
Yvonne Stokes	The University of Adelaide
Jianzhong Su	University of Texas at Arlington
Priya Subramanian	The University of Auckland
Tomoharu Suda	Tokyo University of Science
Haruka Suga	Kyushu University
Tsubasa Sukekawa	Kyoto University
Gowri Priya Sunkara	Louisiana State University
Sergey A. Suslov	Swinburne University of Technology
Winston Sweatman	Massey University
Daisuke Tagami	Kyushu University
Kiyoshi Takeuchi Romo	Australian National University
Alex Tam	Adelaide University
Matthew Tam	The University of Melbourne
Peter Gerrard Taylor	The University of Melbourne
Steve Taylor	The University of Auckland
Natalie Thamwattana	The University of Newcastle
Fangbao Tian	UNSW Canberra
Liam Timms	The University of Melbourne
Chris Tisdell	University of New South Wales
Parul Tiwari	Auckland University of Technology
Ruarai Tobin	The University of Melbourne
Nataliya Togobytska	HTW Berlin - University of Applied Sciences
Eloise Tredenick	University of Canberra

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Katharine Turner	Australian National University
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FIAZ UR REHMAN	Monash University
Graeme Wake	Massey University
Matthew Walker	The University of Melbourne
Weisheng Wang	RMIT University
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Simon Watt	UNSW Canberra
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Ben Wilks	University of South Australia
Thomas Williams	The University of Melbourne
Stephen Woodcock	University of Technology Sydney
Ying Xie	Kyoto University
Xinyi Yang	The University of Melbourne
Liu hao Yu	The University of Auckland
Adriana Zanca	The University of Melbourne
Stefan Zecevic	University of Wollongong
Zhou Zhou	The University of Sydney
Ilze Ziedins	The University of Auckland