Australian Mathematical Society
Australian and New Zealand Industrial and Applied Mathematics

Proceedings of the 49th ANZIAM Conference

Newcastle, New South Wales
3–7 February 2013

The abstracts of the talks in this volume were set individually by the 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.

Published by The University of Newcastle and ANZIAM
Edited by David Allingham, Roslyn Hickson, Bishnu Lamichhane and Mike Meylan

Email: anziam2013@newcastle.edu.au
Web: http://anziam2013.newcastle.edu.au

ISBN: 978-0-9873276-1-1

Contents

1 President's Welcome

On behalf of ANZIAM and SIAM, welcome to the 49th annual ANZIAM conference. These conferences have a long tradition of running in a relaxed, convivial style, often in a resort location. I have found the ANZIAM conferences to be the most enjoyable of all the regular meetings that I have attended. Speakers offer a good spread of topics in applied mathematics but the event is not so large that you can lose your colleagues. ANZIAM is a friendly community, with the older members keen to encourage the next generation.

I have every confidence in the local organising team and in the coastal location with the range of amenities that Newcastle has to offer. This year we again have an impressive array of invited speakers. I hope that your talks go well, that you find something to kindle your interest and that you have a great time with your ANZIAM friends.

Philip Broadbridge
President ANZIAM
Member SIAM

2 Director's Welcome

Welcome to the 2013 ANZIAM meeting being held in conjunction with SIAM, and welcome also to Newcastle and its many beaches.

It is a pleasure to thank the members of the invited speakers committee for their assistance in building the program. I hope that we have been able to provide a selection of distinguished Plenary speakers to cater to the wide interests of the ANZIAM community of researchers and research students.

It is an equal pleasure to thank my colleagues in Newcastle for the hard work they have put into the many components of a successful meeting, from web resources and scheduling to the awards dinner and other social events.

Finally, I need to thank the various sponsors whose logos are listed at the beginning of the timetable and without whose support we would have had a much less successful meeting.

It is said of a good scientific meeting that one comes for the formal program but benefits most from the informal interactions and social events. This is especially true of the culture of the annual ANZIAM meeting. I hope you enjoy all parts of the 2013 ANZIAM meeting.

Jonathan Borwein
Meeting Director

3 Conference Details and History

3.1 Organising Committee

- Jon Borwein (University of Newcastle) — Meeting director
- Juliane Turner (University of Newcastle) – General administration
- David Allingham (University of Newcastle) – Technical administration
- Roslyn Hickson (University of Newcastle) – Conference advisor
- Natashia Boland (University of Newcastle) – General assistance
- Mike Meylan (University of Newcastle) – Programme organiser
- Bishnu Lamichhane (University of Newcastle) – Programme organiser
- Masoud Talebian (University of Newcastle) – Treasurer
- Philip Broadbridge (La Trobe University) – SIAM representative

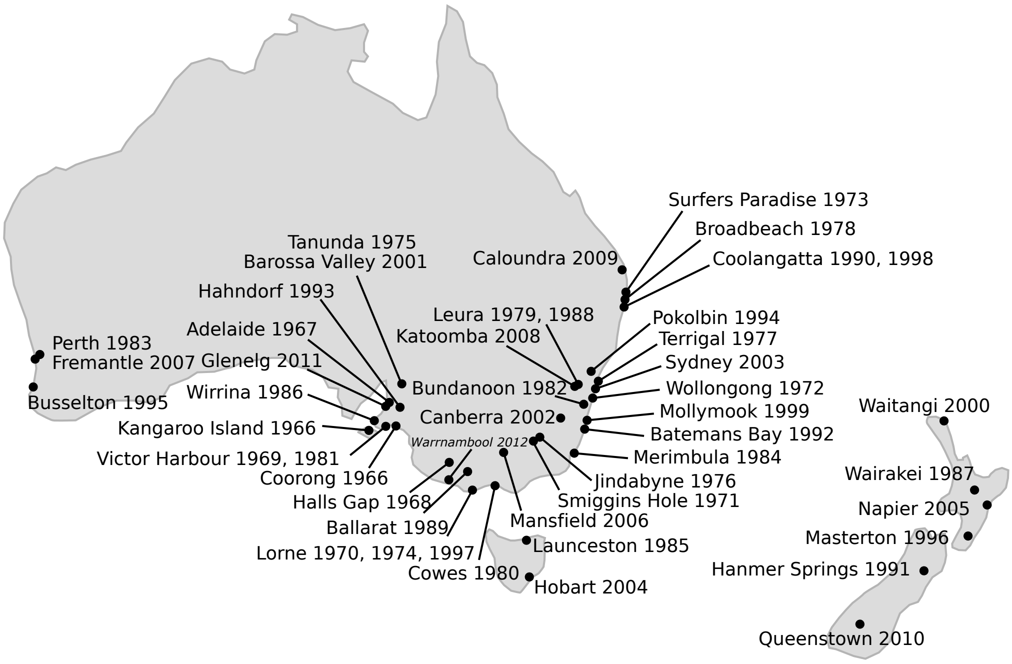
3.2 Invited Speakers Committee

- Larry Forbes (University of Tasmania) — Chairperson
- Jon Borwein (University of Newcastle)
- Carlo Laing (Massey University)
- Natashia Boland (University of Newcastle)
- Geoffry Mercer (Australian National University)
- Irene Hudson (University of Newcastle)
- Kerry Landman (University of Melbourne)
- Kerrie Mengersen (Queensland Institute of Technology)
- Mary Myerscough (University of Sydney)
- John Sader (University of Melbourne)

3.3 Invited Speakers

- Heinz Bauschke (The University of British Columbia, Okanagan) [Page 35]
- Keith Devlin (Stanford University) [Page 35]
- Matthias Ehrgott (University of Auckland) [Page 36]
  CARMA/AMSI Speaker for Mathematics of Planet Earth
- G. Bard Ermentrout (University of Pittsburgh) [Page 36]
- Chris Glasbey (BIOSS Edinburgh) [Page 37]
- Graeme Hocking (Murdoch University) [Page 37]
- Hanna Kokko (The Australian National University) [Page 38]
- Robert McKibbin (Massey University) [Page 38]
  ANZIAM Medalist
- Matthew Simpson (Queensland University of Technology) [Page 39]
  Michell Medalist

3.4 Past Conference Locations



1966	Kangaroo Island (August)
1966	Coorong (December)
1967	Adelaide
1968	Hall's Gap
1969	Victor Harbor
1970	Lorne
1971	Smiggin's Hole
1972	Wollongong
1973	Surfers Paradise
1974	Lorne
1975	Tanunda
1976	Jindabyne
1977	Terrigal
1978	Broadbeach
1979	Leura
1980	Cowes
1981	Victor Harbor
1982	Bundanoon
1983	Perth
1984	Merimbula
1985	Launceston
1986	Wirrina
1987	Wairakei
1988	Leura
1989	Ballarat
1990	Coolangatta
1991	Hanmer Springs
1992	Bateman's Bay
1993	Hahndorf
1994	Pokolbin
1995	Busselton
1996	Masterton
1997	Lorne
1998	Coolangatta
1999	Mollymook
2000	Waitangi
2001	Barossa Valley
2002	Canberra
2003	Sydney
2004	Hobart
2005	Napier
2006	Mansfield
2007	Fremantle
2008	Katoomba
2009	Caloundra
2010	Queenstown
2011	Glenelg
2012	Warrnambool

3.5 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	The University of Adelaide
1970	J. Rickard	University College London
1971	J. Jones	Mount Stromlo
1974	R. P. Oertel	The University of Adelaide
1975	R. E. Robinson	The University of Sydney
1976	J. P. Abbott	Australian National University
1977	J. Finnigan	CSIRO
	S. Bhaskaran	The University of Adelaide
1978	B. Hughes	Australian National University
	P. Robinson	The University of Queensland
1979	J. R. Coleby	The University of Adelaide
	B. Hughes	Australian National University
1980	M. Lukas	Australian National University
1981	A. Plank	The University of New South Wales
1982	G. Fulford	University of Wollongong
	J. Gear	The University of Melbourne
1983	P. Kovesi	The University of Western Australia
1984	A. Kucera	University of Wollongong
	S. Wright	The University of Queensland
1985	G. Fulford	University of Wollongong
	F. Murrell	The University of Melbourne
1986	A. Becker	Monash University
	K. Thalassoudis	The University of Adelaide
1987	M. Rumsewicz	The University of Adelaide
1988	W. Henry	Australian National University
1989	M. Myerscough	University of Oxford
	J. Roberts	The University of Melbourne
1990	J. Best	University of Wollongong
1991	S. K. Lucas	The University of Sydney
	A. Tordesillas	University of Wollongong
1992	S. F. Brown	The University of Sydney
1993	D. Standingford	The University of Adelaide
1994	B. Barnes	Monash University
1995	A. Buryak	Australian National University
1996	A. Gore	The University of Newcastle
	D. Scullen	The University of Adelaide
1997	S. Cummins	Monash University
1998	J. Clark	The University of Sydney
	T. Gourlay	The University of Adelaide
1999	E. Ostrovskaya	Australian National University
2000	C. Reid	Massey University
2001	M. Haese	The University of Adelaide
2002	V. Gubernov	Australian Defence Force Academy
	W. Megill	University of British Columbia/University of Wollongong
2004	K. Mustapha	The University of New South Wales
2005	J. Looker	The University of Melbourne
2006	C. Fricke	The University of Melbourne
2007	S. Harper	Massey University
2008	E. Button	The University of Melbourne
	M. Haythorpe	University of South Australia

2009	S. Cohen	The University of Adelaide
2010	L. Mitchell	The University of Sydney
2011	S. Butler	The University of Sydney
	J. Caffrey	The University of Melbourne
2012	Mr Jason Nassios	The University of Melbourne

3.6 The Cherry Ripe Prize

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

1995	Natashia Boland	The University of Melbourne
1996	Andrew Pullan	The University of Auckland
1997	Neville de Mestre	Bond University
1998	David Stump	The University of Queensland
1999	Mark McGuinness	Wellington University
2000	Joseph Monaghan	Monash University
	Andy Philpott	The University of Auckland
2001	Phil Broadbridge	University of Wollongong
2002	Ernie Tuck	The University of Adelaide
	Larry Forbes	University of Tasmania
2004	Stephen Lucas	University of South Australia
2005	Kerry Landman	The University of Melbourne
2006	Vicky Mak	Deakin University
	James Sneyd	The University of Auckland
2007	Geoffry Mercer	Australian Defence Force Academy
2008	Neville de Mestre	Bond University
2009	Philip Maini	University of Oxford
2010	Larry Forbes	University of Tasmania
2011	Larry Forbes	University of Tasmania
	Darren Crowdy	Imperial College, London
2012	Martin Wechselberger	The University of Sydney

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. The past recipients are listed below.

1999	Harvinder Sidhu	The University of New South Wales
2000	Antoinette Tordesillas	The University of Melbourne
2001	Nigel Bean	The University of Adelaide
2002	Stephen Lucas	University of South Australia
2004	Mark Nelson	University of Wollongong
2006	Sanjeeva Balasuriya	The University of Sydney
2007	Yvonne Stokes	The University of Adelaide
2008	Carlo Laing	Massey University
2009	Scott McCue	Queensland University of Technology
2011	Frances Kuo	The University of New South Wales
2012	Matthew Simpson	Queensland University of Technology

3.8 The 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. The past recipients are listed below.

1995	Renfrey Potts	The University of Adelaide
1997	Ian Sloan	The University of New South Wales
1999	Ernie Tuck	The University of Adelaide
2001	Charles Pearce	The University of Adelaide
2004	Roger Grimshaw	Loughborough University
2006	Graeme Wake	Massey University
2008	James Hill	University of Wollongong
2010	Bob Anderssen	CSIRO
2012	Robert McKibbin	Massey University

3.9 Acknowledgements

The Organising Committee gratefully acknowledges the financial support of the Australian and New Zealand Industrial and Applied Mathematics Society, the School of Mathematical and Physical Sciences at the University of Newcastle, Priority Research Centre for Computer-Assisted Research Mathematics and its Applications at the University of Newcastle, the office of the DVC (Research) at the University of Newcastle, the Australian Mathematical Sciences Institute, MapleSoft™, Mathworks®and SolveIT Software.

The Organising Committee is especially thankful to CSIRO for sponsoring the following students to attend the ANZIAM 2013 conference:

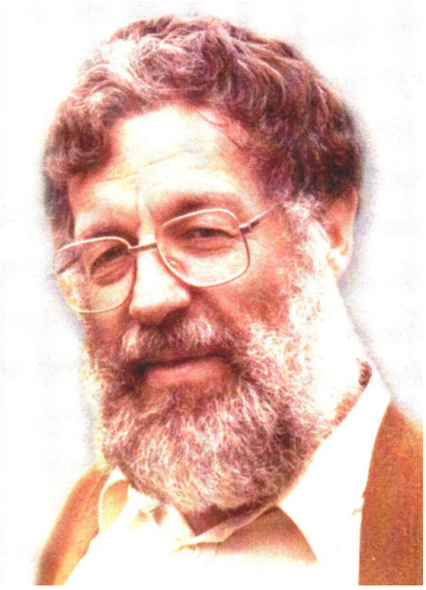
Giles David Adams
Sherin Ahamed
Muteb Alharthi
Julian Back
Rachelle Binny
Rachel Bunder
Meng Cao
Hadi Charkhgard
Sue Ann Chen
Chen Chen
Josh Chopin
Kale Davies
Kathryn Deutscher
Adam James Ellery
Nicholas James Fewster-Young
Brendan Florio
Brendan Harding
Laura Hattam
Andrew Holder
Majda Idlango
Aidan Jalilzadeh
Reena Kapoor
Simranjit Kaur
Daniel Ladiges
Nurul Syaza Abdul Latif
David Lee
Stephen J Maher
Lisa Mayo
Zadrak Ndii Meksianis
Martin Paesold
Catherine Penington
Ravinda Pethiyagoda
Mohsen Reisi
Sebastian Ruther
Lisa Schultz
Luke W Sciberras
Chaitanya Shettigara
Robyn Stuart
Minh Tran
Mingmei Teo
Katrina Treloar
Ying Wan Yap

4 In Memorium

In Memory of

Charles E.M. Pearce

29.3.1940 (Wellington) — 8.6.2012 (West Coast, NZ)



Members of ANZIAM note with sadness the tragic death of Professor Charles Pearce of the University of Adelaide as a result of a motor accident in New Zealand last June. Charles was a well-respected and well-liked member of our community; with an international reputation in probabilistic and statistical modelling and analysis, he made strong contributions to both theory and practice. He also contributed widely to other areas of study, maintaining diverse research interests all his life.

Born in New Zealand, with partial Maori ancestry, he undertook all of his pre-doctoral education there. With an Australian Ph.D. (at ANU), followed by academic positions in Australia, he was very much in the forefront of the ANZIAM spirit as it embraced our two countries. He served as long-time Editor of our ANZIAM Journal until quite recently, and was the winner of our most prestigious award, the ANZIAM Medal, in 2001.

In 2007 he was awarded the Potts Medal by the Australian Society for Operations Research, for outstanding contributions to operations research in Australia. He was a Fellow of both the Australian Mathematical Society and the New Zealand Mathematical Society. He was also co-author, with his wife Fran, of a remarkable scholarly work, *Oceanic Migrations* (Springer, Population Studies (2010)). It was during one of his trips to remote New Zealand, furthering his studies into Maori migration, that he lost his life.

In November 2012, the 12th International Symposium on Mathematical and Computational Biology (BIOMAT 2012) in Tempe Arizona dedicated its conference to the work undertaken by Charles. He is greatly missed by so many. We extend our heartfelt sympathy to Fran and family.

Graeme Wake (Auckland)

Andrew Eberhard (Melbourne)

5 Conference Events, Venues and Facilities

5.1 Conference Welcome Reception

A barbecue welcome reception will be held from **6pm on Sunday 3 February** at the Newcastle Museum, Workshop Way, Newcastle. All delegates and their registered guests are invited.

5.2 Award Ceremony and Conference Dinner

The ANZIAM Annual Award Ceremony and conference dinner will be held in the Promenade Ballroom at Noah's on the Beach, with pre-dinner drinks and canapés from 7.00pm on Wednesday 6 February with dinner starting at 7.30pm. Tickets are $100 per person and must be purchased in advance, either via the conference website prior to the start of the conference or at the conference registration desk before 4 February.

5.3 Morning and Afternoon Teas and Lunches

Morning and afternoon tea and lunch will be available in the Banquet Room at the venue. All refreshments are included in the registration fee for delegates and their registered guests.

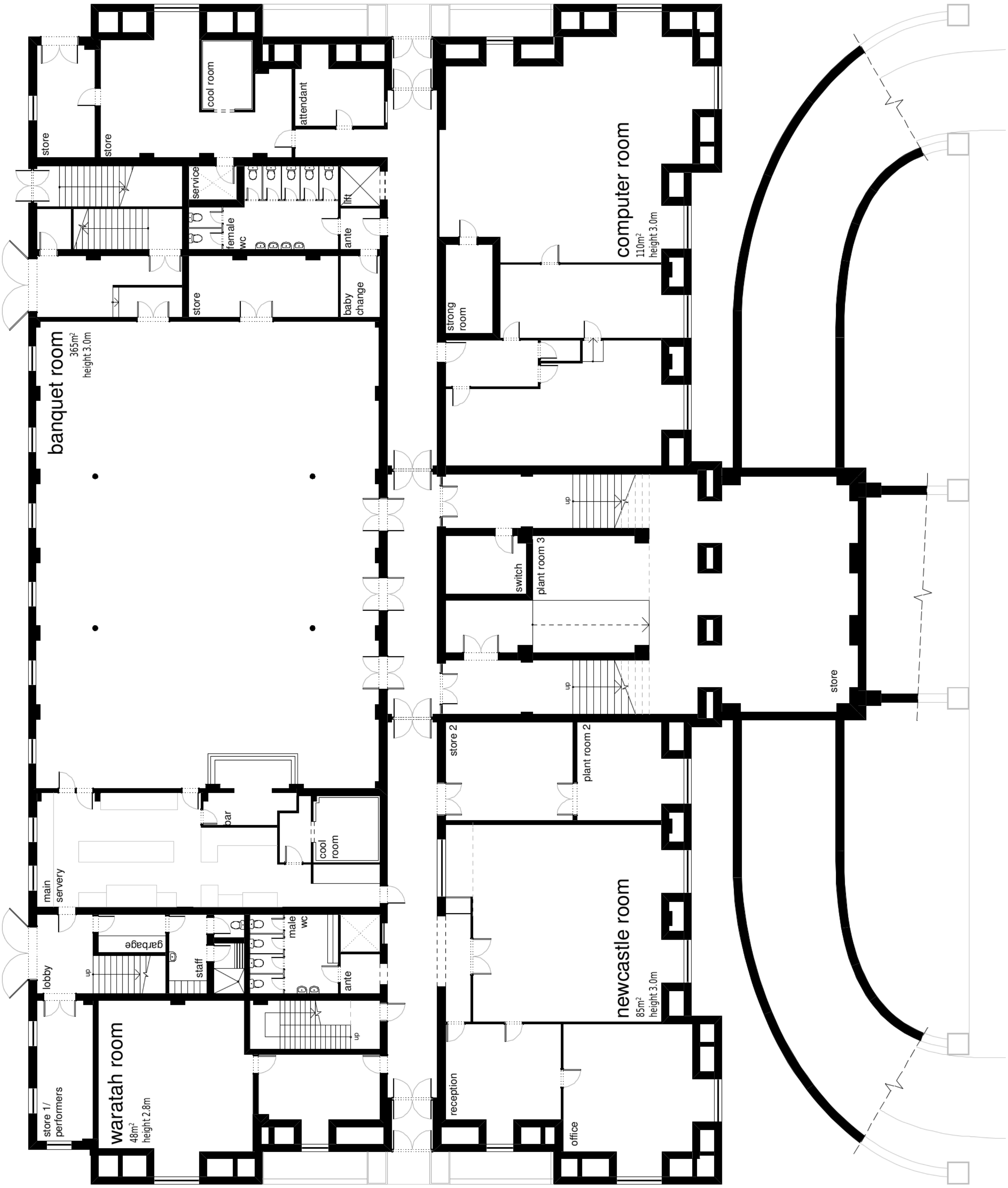
5.4 Internet Access

Free wireless internet access is available at the venue. Please ask at the reception desk for a password.

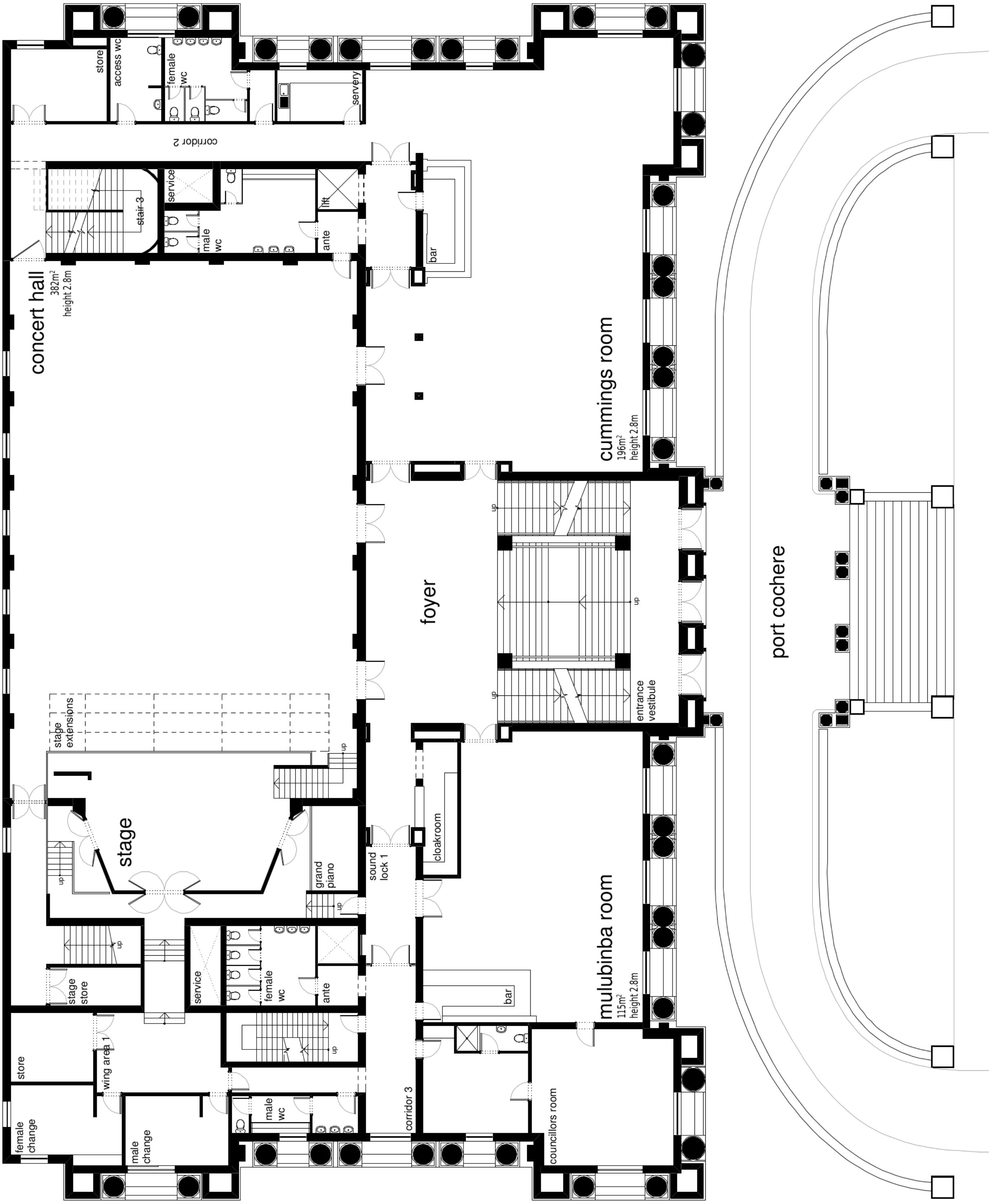
5.5 Plenary Lectures and Contributed Talks

All invited plenary lectures will take place in the Concert Hall. Contributed talks will be held in four parallel sessions in the Cumming Room, Mulubinba Room, Hunter Room and Newcastle Room; see the following pages for venue plans. The duration of each contributed talk will be fifteen minutes with an additional five minutes for questions and room changes.

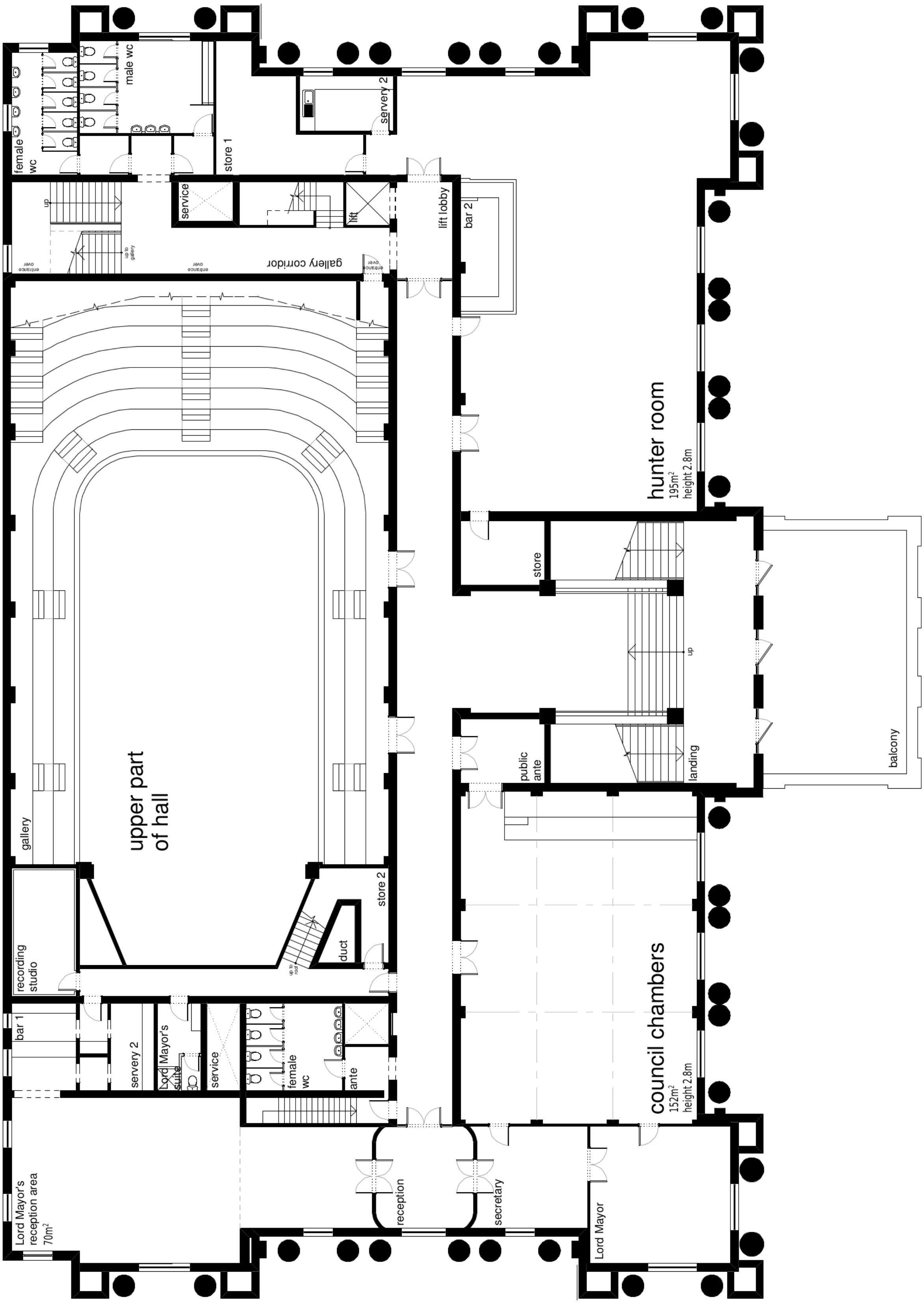

NOAH'S ON THE BEACH
FORESHORE PARK
NEWCASTLE STATION
CATHEDRAL
MUSEUM
CIVIC STATION
CITY HALL



Newcastle City Hall: Ground Floor



Newcastle City Hall: First Floor



Newcastle City Hall: Second Floor

6 Programme Overview

All meetings and other events listed below will be held in the Newcastle City Hall unless otherwise specified.

Sunday

10:00 am	AustMS steering committee meeting — invitation only
2:00 pm–5:00 pm	Conference registration
3:00 pm	ANZIAM executive meeting (Noah's on the Beach) — invitation only
6:00 pm	Welcome Reception (Newcastle Museum)

Monday

8:30 am–8:45 am	Conference registration
8:45 am–9:00 am	**Conference opening**
9:00 am–1:20 pm	**Talks**
1:20 pm–2:20 pm	Lunch
2:20 pm–6:00 pm	**Talks**
7:00 pm	Student BBQ (Foreshore Park, western end)
8:00 pm	Maths Biology Special Interest Group meeting

Tuesday

8:30 am–9:00 am	Conference registration
9:00 am–1:20 pm	**Talks**
1:20 pm–2:00 pm	Lunch
2:00 pm	Organised Tours
7:30 pm	ANZIAM AGM

Wednesday

8:30 am–9:00 am	Conference registration
9:00 am–1:20 pm	**Talks**
1:20 pm–2:10 pm	Lunch
2:10 pm–5:40 pm	**Talks**
7:00 pm	ANZIAM Annual Award Ceremony and Conference Dinner (Noah's on the Beach)

Thursday

8:30 am–9:00 am	Conference registration
9:00 am–1:00 pm	**Talks**
1:00 pm–2:00 pm	Lunch

In co-operation with

7 Timetable

Contributed talks are 15 minutes long, plus up to 5 minutes for questions. Session times will be strictly adhered to, to allow people to move between the parallel streams. The † symbol denotes a student talk. The programme below was correct at time of printing; please visit `http://anziam2013.newcastle.edu.au/programme.html` for amendments.

Sunday (3rd February)

Stream:	Newcastle Room	Mulubinba Room	Cummings Room	Hunter Room
2:00 pm	Conference Registration			
6:00 pm	Conference Reception			

Monday (4th February)

Stream:	Newcastle Room	Mulubinba Room	Cummings Room	Hunter Room	Concert Hall
8:30 am	Conference Registration				
8:45 am	Conference Opening				
9:00 am	Keynote 1. Chairperson: Laureate Prof. Jon Borwein **Dr Heinz Bauschke** *An Invitation to Modern Projection Methods* [Page 35]				
Chairperson:	Roslyn Hickson	Simon Clarke	Boris Baeumer	Martin Savelsbergh	Mike Meylan
10:00 am	**Mr Andrew Holder†** *Acid-mediated tumour growth* [Page 65]	**Prof. Larry Forbes** *Solitons in Combustion – A Meeting of Two Old Flames* [Page 58]	**Dr Winston Sweatman** *Outcomes of Binary Scattering at High Energies* [Page 94]	**Prof. David Y Gao** *Unified Understanding for Complex Systems and NP-Hard Problems in Computational Mathematics and Sciences* [Page 60]	**Mr Nicholas Fewster-Young†** *Deceptive solutions to singular boundary value problems.* [Page 57]
10:20 am	**Mr Meksianis Zadrak Ndii†** *Dengue and mosquitoes: can we stop transmission?* [Page 80]	**A/Prof. Michael Page** *Some novel diffusion-driven flows* [Page 82]	**Dr Galyna Safonova** *Accurate solution to the scattering problem for arrays of infinitely long cylinders* [Page 87]	**Mr Stephen Maher†** *Solving the integrated airline recovery problem using column-and-row generation* [Page 75]	**Mr Jason Cosgrove†** *Large-scale atmospheric vortices* [Page 51]

Continued on next page

Monday (4th February)

Stream:	Newcastle Room	Mulubinba Room	Cummings Room	Hunter Room	Concert Hall
10:40 am	**Dr Borislav Savkovic** *Mathematical modelling in anti-HIV gene therapy: estimating clinically relevant parameters and predicting likely clinical outcomes* [Page 87]	**Luke Sciberras†** *Propagation and stability of vortices in bounded nonlocal nonlinear media* [Page 89]	**Giang Nguyen** *Phase-Type Poisson distributions (like Poisson, but different)* [Page 81]	**Ms Reena Kapoor†** *Optimising Reclaimer Schedules* [Page 68]	**Mr David Horsley†** *Faraday waves in radial outflow* [Page 66]
11:00 am	Morning Tea Monday				
11:20 am	Keynote 2. Chairperson: Prof. Natashia Boland **Prof. Matthias Ehrgott** *Bridging the gap between real world decision making and mathematics – Multi-objective optimisation in action* [Page 36]				
Chairperson:	Geoff Mercer	Robert McKibbin	Bob Anderssen	Mark Fackrell	Bishnu Lamichhane
12:20 pm	**Dr James Gilmore** *Understanding first phase HIV decay dynamics through stage-dependent drug action* [Page 61]	**Mr Meng Cao†** *3D modelling of suspended sediment transport in turbulent open channel fluids* [Page 48]	**A/Prof. Harvi Sidhu** *Travelling waves in a competitive reaction scheme* [Page 91]	**Isaac Donnelly†** *Pattern Formation on Networks with Reactions: A Continuous Time Random Walk Approach* [Page 54]	**Lisa Mayo†** *Numerical solutions for thin film flow down the outside and inside of a vertical cylinder* [Page 76]
12:40 pm	**Catherine Penington†** *Collective motion of dimers* [Page 83]	**Dr Collin Phillips** *Rapidly Rotating Anisotropic $\boldsymbol{\alpha}$-effect Dynamos* [Page 84]	**Mr Adam Ellery†** *Moments of action for diffusion-reaction-advection processes.* [Page 55]	**Mr Giles David Adams†** *Equilibria and Optimisation: An interesting approach from the study of selfish networks* [Page 41]	**Dr Michael Brideson** *The Bernoulli Equation in PDE form modelling Interfacial Fluid Flows* [Page 47]
1:00 pm	**Mr David Khoury†** *Using models to uncover dynamical features of malaria infections that are difficult to measure* [Page 70]	**Ravindra Pethiyagoda†** *Accurate numerical simulations of three-dimensional ship wave patterns.* [Page 83]	**Mr Chen Chen†** *Multiscale modelling of diffusion in a material with microstructures* [Page 50]	**Dr Dion O'Neale** *Using network science to explore innovation* [Page 81]	**A/Prof. Annette Worthy** *Generation and Control of Solitons using Various Nematic Geometries and Regimes* [Page 100]
1:20 pm	Lunch Monday				
2:20 pm	Keynote 3. Chairperson: Prof. Larry Forbes **Prof. Graeme Hocking** *Theory and practice of withdrawal from stratified reservoirs* [Page 37]				

Continued on next page

Monday (4th February)

Stream:	Newcastle Room	Mulubinba Room	Cummings Room	Hunter Room	Concert Hall
Chairperson:	Mick Roberts	Larry Forbes	Markus Hegland	Dion O'Neale	Annette Worthy
3:20 pm	**Miss Nurul Syaza Abdul Latif**† *Modelling induced resistance to plant disease using dynamical systems* [Page 41]	**Prof. John Harper** *Bubble electrophoresis with four univalent ion species* [Page 63]	**Dr Mike Meylan** *Modelling Wave Attenuation in the Marginal Ice Zone* [Page 78]	**Mr Philip Howes**† *Living on the edge of chaos: Painlev equations through geometry* [Page 66]	**Mr Erwin Lobo**† *Pathways of Carcinogenesis: Tumour Progression and Treatments* [Page 74]
3:40 pm	**Dr Robert Smith?** *A mathematical model of Bieber Fever: The most infectious disease of our time?* [Page 92]	**Miss Ying Wan Yap**† *Numerical study of oscillatory Couette flow in rarefied gas* [Page 101]	**Martin Seydenschwanz**† *An Implicit Discretization Scheme for Linear-Quadratic Control Problems with Bang-Bang Solutions* [Page 90]	**Andreas Loehne** *Linear vector optimization – algorithms and applications* [Page 75]	**Mr Michael Lachut**† *Buckling of a cantilever plate uniformly loaded in its plane with applications to surface stress and thermal loads* [Page 72]
4:00 pm	**A/Prof. Geoffry Mercer** *Complex behavior in a dengue model with a seasonally varying vector population* [Page 77]	**Sue Ann Chen**† *Motion of a clean bubble past a surface* [Page 50]	**Mr Peter Cudmore**† *Synchronisation and amplitude death in Nanomechanical Oscillators* [Page 52]	**Matthias Wong**† *The sparse grid combination technique for multi-dimensional problems* [Page 100]	**Dr Yalcin Kaya** *Constructing Interpolating Curves via Optimal Control* [Page 69]
4:20 pm	Afternoon Tea Monday				
Chairperson:	Stan Miklavcic	John Harper	Yalcin Kaya	Masoud Talebian	Natashia Boland
4:40 pm	**Mr Alexander Chalmers**† *Mathematical Modelling of Atherosclerosis: A disease of boundary conditions* [Page 49]	**Mr Muteb Alharthi**† *Feedback control for reaction-diffusion-delay equations: semi-analytical solutions* [Page 42]	**Prof. Markus Hegland** *On the numerical solution of the Vlasov-Maxwell equations* [Page 64]	**Prof. Peter Taylor** *A Microeconomic Model for Journal Revenue Sourcing* [Page 94]	**Ms Chaitanya Shettigara**† *Challenges in Numerical Relativity* [Page 91]
5:00 pm	**Prof. Nigel Bean** *Health benefits: Do they add up?* [Page 44]	**Quoc Thong Le Gia** *Multiscale methods for the Stokes problem on bounded domains* [Page 73]	**Ms Robyn Stuart**† *Metastability in Dynamical Systems* [Page 93]	**Benjamin Weißing**† *Set-valued Average Value at Risk* [Page 99]	**Mr Bennett Gardiner**† *Saffman-Taylor fingers in a wedge geometry* [Page 60]

Continued on next page

Monday (4th February)

Stream:	Newcastle Room	Mulubinba Room	Cummings Room	Hunter Room	Concert Hall
5:20 pm	**Catheryn Gray**† *Local Sensitivity Analysis of Glucose Transporter Translocation in Response to Insulin* [Page 61]	**Mr Hayden Tronnolone**† *Complex-variable methods for surface-tension-driven viscous flows in two-dimensional multiply-connected domains* [Page 97]	**Dr Bronwyn Hajek** *Heat conduction in a heterogeneous cooling fin – some interesting non-classical symmetry solutions* [Page 62]	**Mr Alex Badran**† *Consistent Modelling of VIX and Equity Derivatives Using a 3/2 Plus Jumps Model* [Page 43]	**Dr Paul Leopardi** *Alignment-free comparison of biological sequences* [Page 74]
5:40 pm	**Dr Joshua Ross** *How big is an outbreak likely to be?* [Page 86]	**Prof. Darren Crowdy** *Stokes flows in confined domains* [Page 51]	**Kathryn Deutscher**† *Unstable Klein-Gordon Modes in an accelerating universe* [Page 54]	**Mr Yang Shen**† *Pricing bond options under a Markovian regime-switching HullWhite model* [Page 91]	**Mr Martin Paesold**† *Non-equilibrium thermodynamics of folding in geomaterials* [Page 82]

Tuesday (5th February)

Stream:	Newcastle Room	Mulubinba Room	Cummings Room	Hunter Room
8:30 am	Conference Registration			
9:00 am	Keynote 4. Chairperson: A/Prof. Carlo Laing **Prof. G. Bard Ermentrout** *When Noise is the Signal: Stochastic Synchrony* [Page 36]			
Chairperson:	Nigel Bean	Frank de Hoog	Winston Sweatman	Frances Kuo
10:00 am	**A/Prof. John Murray** *Operations research extracting response to antiviral therapy for hepatitis C virus envelope sequences* [Page 79]	**Mr Michael Dallaston**† *Nongeneric bubble extinction in a Hele–Shaw cell* [Page 52]	**Laura Hattam**† *Modulation Theory for the Steady fKdVB Equation- Constructing Periodic Solutions* [Page 64]	**Mr David Farmer**† *Chebychev-collocation method for non-linear time-stepping problems* [Page 57]
10:20 am	**Mr John Mitry**† *Ducks on Drugs: Folded saddle canards in a model of propofol anaesthesia* [Page 78]	**A/Prof. Sergey Suslov** *Thermomagnetic and sedimentation effects on convection in ferrofluid: theory and experiment* [Page 93]	**Dr Boris Baeumer** *Stable Processes with Boundary Constraints and Fractional Cauchy Problems* [Page 44]	**Mr Andrew Stephan**† *Generalised Compact Finite Difference Methods* [Page 92]
10:40 am	**Dr James McCaw** *Intriguing nonlinearity in a SIRS model of disease transmission with immune boosting* [Page 76]	**Mr Daniel Ladiges**† *A Modified DSMC Method for Simulating Unsteady Flows* [Page 72]	**Mrs Hala Hejazi**† *A second-order accurate finite volume method for solving the two-sided space fractional diffusion equation* [Page 65]	**Mrs Lucy Leigh**† *What to do when scheduling is not followed - the issue of unbalanced longitudinal data* [Page 74]
11:00 am	Morning Tea Tuesday			
11:20 am	Keynote 5. Chairperson: Laureate Prof. Jon Borwein **Prof. Keith Devlin** *A uniform mathematical view of the modern battlefield* [Page 35]			
Chairperson:	Joshua Ross	Darren Crowdy	Michael Page	Phil Broadbridge
12:20 pm	**Prof. Mick Roberts** *How epidemiology interacts with ecology* [Page 85]	**Mr Julian Back**† *Finite-time blow-up of one- and two- dimensional Stefan problems* [Page 43]	**Dr David Ivers** *Dynamos in Spheroidal and Ellipsoidal Geometries* [Page 67]	**Dr Dirk Nuyens** *A multilevel algorithm for box integrals on string generated Cantor sets* [Page 81]
12:40 pm	**Dr Timothy Schaerf** *Rules of attraction, repulsion, orientation and streaking a model for the guidance and motion of honey bee swarms* [Page 88]	**Dr Yvonne Stokes** *Thin-film flow in helically-wound channels with small torsion.* [Page 92]	**Mr David Lee**† *Envelope Solitons in Barotropic and Baroclinic Flows* [Page 73]	**Mr Darren Engwirda**† *Algorithms for Dynamic Quadrilateral-Dominant Tessellation* [Page 56]
1:00 pm	**A/Prof. Mary Myerscough** *Brood, food and collapse: A delay differential equation model for honey bee demography.* [Page 79]	**Dr Debadi Chakraborty** *Extensional acoustic vibrations of axisymmetric nanoparticles immersed in viscous fluids* [Page 48]	**Mr Brendan Florio**† *The interaction of convection modes in a box of a porous medium* [Page 58]	**Christopher Schneider**† *L^1-Regularization of Linear-Quadratic Control Problems* [Page 88]

Continued on next page

Tuesday (5th February)

Stream:	Newcastle Room	Mulubinba Room	Cummings Room	Hunter Room
1:20 pm	Lunch Tuesday			
2:00 pm	Organised Tours			

Wednesday (6th February)

Stream:	Newcastle Room	Mulubinba Room	Cummings Room	Hunter Room
8:30 am	Conference Registration			
9:00 am	Keynote 6. Chairperson: A/Prof. Geoffry Mercer **Prof. Hanna Kokko** *Is Mother Nature shortsighted? Evolutionary processes do not maximize population performance* [Page 38]			
Chairperson:	John Murray	John Boland	Thanh Tran	Peter Taylor
10:00 am	**Mrs Majda Idlango†** *Transition Analysis of a Single Species Logistic Model Exhibiting an Allee Effect in a Slow Variation* [Page 67]	**Dr Reiichiro Kawai** *On weak approximation of stochastic differential equations through hard bounds by mathematical programming* [Page 69]	**Dr Petrus van Heijster** *Travelling spots in a three-component FitzHugh-Nagumo equation* [Page 97]	**Mr Mohsen Reisi†** *Demand Driven Throughput Assessment for Hunter Valley Coal Chain* [Page 85]
10:20 am	**Prof. Graeme Wake** *A model of asymmetric cell division: implications for tumour biology and some new non-local calculus* [Page 98]	**Dr Narin Petrot** *Generalized Distance and fuzzy Concepts for Fixed Point Problems in metric spaces* [Page 84]	**Miss Lisa Schultz†** *Modelling South Australian Motor Vehicle Emissions and Exposure Risk Analysis* [Page 89]	**Christoph Kowitz†** *An optimized combination technique for the gyrokinetic eigenvalue problem* [Page 70]
10:40 am	**Bob (Robert) Anderssen** *Modelling Microbial Growth in a Closed Environment* [Page 43]	**Miss Mingmei Teo†** *Markov chains with interval transition probabilities* [Page 95]	**Dr Federico Frascoli** *Anti-tumor immunity and growing cancers: a dynamical system approach* [Page 59]	**Ms Simranjit Kaur†** *Scheduling unit processing time arc shutdown jobs to maximize network flow over time* [Page 68]
11:00 am	Morning Tea Wednesday			
11:20 am	Keynote 7. Chairperson: Prof. Irene Hudson **Prof. Chris Glasbey** *Dynamic programming versus graph cut algorithms for phenotyping by image analysis* [Page 37]			
Chairperson:	Graeme Wake	Xianfu Wang	Robert Smith?	Regina Burachik
12:20 pm	**Mr Aidin Jalilzadeh†** *Modelling Tissue Inflammatory Response: Chemotaxis-Reaction-Diffusion Equations (CRDEs)* [Page 67]	**Miss Katrina Treloar†** *Velocity-jump processes with proliferation* [Page 96]	**Dr Andrew Black** *Mixing times in evolutionary game dynamics* [Page 45]	**Mr James Foster†** *Optimal approximation for nonconvex quadratic optimization* [Page 59]
12:40 pm	**Mr Theodore Vo†** *Combining Mathematics and Electrophysiology to Understand Bursting in Pituitary Cells* [Page 98]	**Wiyada Kumam†** *The Linear Regression and Fuzzy Linear Regression based Medical Service Value Models for Informal Workers in Thailand* [Page 71]	**Dr Mike Plank** *So long and thanks for all the fish* [Page 84]	**Mr Hadi Charkhgard†** *Optimising Order Batching* [Page 49]
1:00 pm	**Prof. Irene Hudson** *Drug-likeness: statistical tools, chemicobiology space, cartesian planes, drug databases: a case study* [Page 66]	**Mr Brendan Harding†** *A stochastic model for effect of hardware faults on supercomputers* [Page 62]	**Mr Josh Chopin†** *Mathematical and Computational Modelling for the Phenotypic Analysis of Cereal Plants* [Page 50]	**Mr Sanjoy Kumar Paul†** *A Production-Inventory System with Disruption and Reliability Considerations* [Page 83]

Continued on next page

Wednesday (6th February)

Stream:	Newcastle Room	Mulubinba Room	Cummings Room	Hunter Room
1:20 pm	Lunch Wednesday			
2:10 pm	Keynote 8. Chairperson: Dr Frances Kuo **Dr Matthew Simpson** *Collective cell behaviour with clustering* [Page 39]			
Chairperson:	Mary Myerscough	Andrew Black	Dirk Nuyens	David Y Gao
2:40 pm	**Kristen Harley**† *Shock-fronted travelling wave solutions arising in a model of tumour invasion* [Page 63]	**Mr Duy Tran**† *Geographically clustering New Zealand electorates in the 1893 general election using data describing gender and voter turnout; an application of the Aggregate Association Index* [Page 95]	**Dr Jerome Droniou** *Gradient schemes for diffusion equations* [Page 54]	**Sherin Ahamed**† *Modelling rainfall on various time scales* [Page 42]
3:00 pm	**Miss Rachelle Binny**† *Mathematical Modelling of Cell Invasion* [Page 45]	**Ms Sidra Zafar**† *An overview of estimation for ordinal log-linear models* [Page 101]	**Dr Simon Clarke** *Symmetric solutions to the forced extended Korteweg-de Vries equation* [Page 51]	**Ms Rachel Bunder**† *An Integer Programming Approach to Picking Items for Experimental Sets* [Page 47]
3:20 pm	**Mr Fehaid Alshammari**† *Corneal Epithelium Wound Healing* [Page 42]	**Mr Salman Cheema**† *On issues concerning the assessment of information contained in aggregate data using the F-test* [Page 49]	**Mrs Syeda Laila Naqvi**† *Adaptive radial basis function for time-dependent partial differential equations by reconstruction through cubic splines* [Page 80]	
3:40 pm	**Ms Sangeeta Bhatia**† *Group theoretic formalization of double-cut-and-join model of chromosomal rearrangement* [Page 45]	**Valeriy Khakhutskyy**† *Parallel Solution of Regression Problems Using Sparse Grids and Alternating Direction Method of Multipliers* [Page 69]	**Minh Tran**† *A New Parallel Algorithm for Solving Tri-diagonal Systems* [Page 96]	**A/Prof. Regina Burachik** *The Exact Penalty Map for Nonsmooth Optimization* [Page 48]
4:00 pm	Afternoon Tea Wednesday			
Chairperson:	Matthew Simpson	Mike Plank	Jerome Droniou	
4:20 pm	**Prof. Stan Miklavcic** *Mathematical modelling of salt and water uptake and transport in plant roots* [Page 78]	**Mr Michael Rose**† *Expectations on Fractal Sets* [Page 86]	**Mr Kale Davies**† *Continuum modelling and the assumption of homogenous mixing: The importance of being spatially aware* [Page 53]	

Continued on next page

Wednesday (6th February)

Stream:	Newcastle Room	Mulubinba Room	Cummings Room	Hunter Room
4:40 pm	**A/Prof. Scott McCue** *Multiscale modelling of sausage-shaped cell migration leads to a continuum description with degenerate diffusion* [Page 76]	**Dr Gobert Lee** *Statistical Inference and Medical Image Segmentation* [Page 73]	**Prof. Tony Roberts** *A new approach supports slowly varying and thin layer PDE models* [Page 86]	
5:00 pm	**Dr Shawn Means** *Mitochondrial Calcium Handling and the Interstitial Cells of Cajal* [Page 77]	**Prof. John Boland** *Statistical Analysis in Energy Meteorology* [Page 46]	**A/Prof. Thanh Tran** *Solving geodesic problems on a sphere with spherical splines* [Page 96]	
5:20 pm	**Dr Jeremy Sumner** *Lie Markov Models and why they matter to phylogenetics* [Page 93]	**Dr Frank de Hoog** *Approximating the Intensity of a Point Process* [Page 53]	**Dr Sheehan Olver** *Sparse and stable spectral methods* [Page 82]	
7:00 pm	ANZIAM Annual Award Ceremony and Conference Dinner			

Thursday (7th February)

Stream:	Newcastle Room	Mulubinba Room	Cummings Room	Hunter Room
8:30 am	Conference Registration			
9:00 am	Keynote 9. Chairperson: Dr Bob Anderssen **Prof. Robert McKibbin** *Geofizz Unfazed* [Page 38]			
Chairperson:	Gary Froyland	Carlo Laing	Tony Roberts	Matthias Ehrgott
10:00 am	**Dr Jason Sharples** *Modelling dynamic fire spread mechanisms* [Page 90]	**Dr Michael Deakin** *The Ellipsing Pendulum* [Page 53]	**Prof. Dr. Somyot Plubtieng** *Existence theorems for the n-vectorial saddle point problems* [Page 85]	**Prof. Andrew Eberhard** *An interpretation of a feasiblity algorithm in Integer programming* [Page 55]
10:20 am	**Dr Ngamta Thamwattana** *Using calculus of variations to model polymer chains with non-circular cross sections* [Page 95]	**A/Prof. Martin Wechselberger** *Canards and Excitability* [Page 99]	**Dr Shuaian Wang** *Global Optimization Methods for the Discrete Network Design Problem* [Page 98]	**Prof. Martin Savelsbergh** *A new algorithm for solving bi-objective 0-1 integer programs* [Page 87]
10:40 am	**Dr Mark Nelson** *The biological treatment of wastewater: modelling a sludge disintegration unit* [Page 80]	**Dr Robert Marangell** *The Morse and Maslov Indices for Periodic Problems* [Page 75]	**Tarek Elgindy** *Electricity Generation and Transmission Network Design Considering Intermittent Supply* [Page 55]	**John** *MIP models for optimisation of locations for prescribed burning* [Page 68]
11:00 am	**Dr Sharleen Harper** *Modelling the Performance of Raingardens as Stormwater Treatment Devices* [Page 63]	**Dr Alona Ben-Tal** *Coarse-graining and simplification of bursting dynamics* [Page 44]	**Dr Poom Kumam** *The best proximity point theorems for generalized proximal contraction mappings* [Page 71]	**Dr Tony P Roberts** *Topology optimization for bone implants and high strength to weight ratio cellular materials* [Page 86]
11:20 am	Morning Tea Thursday			
Chairperson:	Petrus van Heijster	Martin Wechselberger	Hanna Kokko	Andreas Loehne
11:40 am	**Prof. Bill Blyth** *Introduction to Computer Aided Assessment of Advanced Questions using MapleTA* [Page 46]	**Carlo Laing** *Managing heterogeneity in the study of neural oscillator dynamics* [Page 72]	**Prof. Joerg Fliege** *Reformulations of multiobjective bilevel problems* [Page 58]	**Dr Xianfu Wang** *Restricted normal cones and the method of alternating projections* [Page 99]
12:00 pm	**Christian Gerhards** *Multiscale Methods for Geomagnetic Modeling* [Page 61]	**Gary Froyland** *Finite-time entropy: A probabilistic approach for measuring nonlinear stretching in dynamical systems* [Page 59]	**Dr Bishnu Lamichhane** *A mixed finite element method for the biharmonic problem using biorthogonal or quasi-biorthogonal systems* [Page 73]	**Prof. Natashia Boland** *On the Augmented Lagrangian Dual for Integer Programming* [Page 46]

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Thursday (7th February)

Stream:	Newcastle Room	Mulubinba Room	Cummings Room	Hunter Room
12:20 pm	**Prof. Phil Broadbridge** *Ponding Time Under Irrigation: Where Approximate Becomes Exact* [Page 47]	**Dr Frances Kuo** *Multi-level quasi-Monte Carlo finite element methods for a class of elliptic partial differential equations with random coefficients* [Page 71]	**Dr Kasamsuk Ungchittrakool** *An iterative shrinking metric f-projection method for finding a common fixed point of a quasi strict f-pseudo-contraction and a countable family of firmly nonexpansive mappings and applications in Hilbert spaces* [Page 97]	**Dr Mark Fackrell** *Car Allocation in a Vertical Rotary Car Park* [Page 56]
12:40 pm	**A/Prof. Troy Farrell** *Modelling of Large Scale Bagasse Stockpiles* [Page 57]	**Dr Roslyn Hickson** *How population heterogeneity influences epidemic dynamics* [Page 65]	**Dr Michael Haythorpe** *Snakes and Ladders Heuristic for the Hamiltonian Cycle Problem* [Page 64]	**Masoud Talebian** *Pricing to Accelerate Demand Learning in Dynamic Assortment Planning* [Page 94]
1:00 pm	Lunch Thursday			

8 Keynote Abstracts

An Invitation to Modern Projection Methods

Dr Heinz Bauschke
Mathematics
The University of British Columbia
heinz.bauschke@ubc.ca

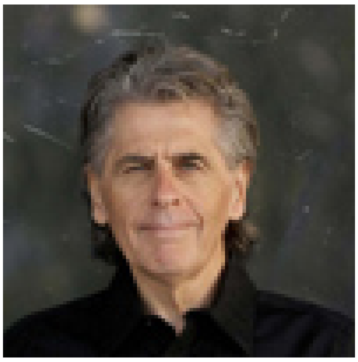
9:00 am Monday

Abstract Feasibility problems, i.e., finding a solution satisfying certain constraints, are common in mathematics and the natural sciences. If the constraints have simple projectors (nearest point mappings), then one popular approach to these problems is to use the projectors in some algorithmic fashion to approximate a solution.

In this talk, I will survey three methods (von Neumann's alternating projections, Dykstra's method, and the Douglas-Rachford method), and comment on recent advances and remaining challenges.

A uniform mathematical view of the modern battlefield

Prof. Keith Devlin
Stanford University
kdevlin@stanford.edu



11:20 am Tuesday

In 2010-11, I conducted a project for the US Army to develop a uniform representation of the modern battlefield that could form the basis for a computer-based reasoning/planning/decision-making system. The framework I developed has the potential to be used in any complex domain where complex human-machine systems operate in a hostile environment, such as offshore oil drilling/pumping and major disaster relief operations.

Bridging the gap between real world decision making and mathematics – Multi-objective optimisation in action

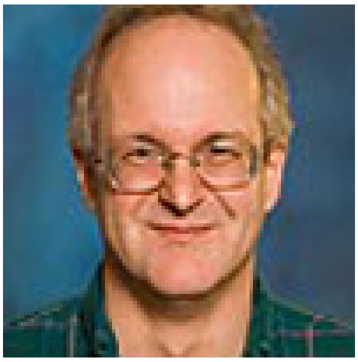
Prof. Matthias Ehrgott
University of Auckland
m.ehrgott@auckland.ac.nz

11:20 am Monday

In this talk I will present several studies that illustrate the power of multi-objective optimisation in supporting decision makers facing conflicting goals. These studies are drawn from the fields of transportation (airline operations, traffic modelling), health (radiation therapy treatment) and manufacturing (composite materials). I will illustrate the widely differing mathematical methods used in these applications and emphasise the common benefits of the multi-objective optimisation approach. These include an improved understanding of the problem achieved through additional insight into the problem structure, improved support for decision makers through the ability to properly account for trade-offs between conflicting goals, and the considerable benefits that result in terms of quality of decisions and/or improved decision making processes.

When Noise is the Signal: Stochastic Synchrony

Prof. G. Bard Ermentrout
University of Pittsburgh
ermentrout@gmail.com



9:00 am Tuesday

For the last seven years, my colleagues and I have analyzed the role that noisy broadband external signals play in the synchronization of biological oscillations. While our work has focused on this phenomena in the nervous system, the basic ideas apply to many other areas of physics and biology. In this talk, I will survey the primary mathematical results that we have developed. We first derive the equations for weak noise perturbations of exponentially stable limit cycles. With this perturbation, it become possible to compute quantities such as Liapunov exponents, diffusion constants, and the effects of noise on frequency. We show that there are resonances between the frequency of the oscillations and the time scale of the noise. Next we apply this theory to synchronization of oscillators that receive partially correlated noise. We derive the invariant density and order parameters for the degree of synchronization. We show that some types of oscillators are better synchronizers than others. We conclude with some surprising effects of heterogeneity on the synchronization.

Dynamic programming versus graph cut algorithms for phenotyping by image analysis

Prof. Chris Glasbey
Biomathematics and Statistics Scotland (BIOSS)
chris@bioss.sari.ac.uk

11:20 am Wednesday

In our post-genomic world, where genetic information is readily available, phenotyping (i.e. measuring the observable characteristics of plants and animals) is often the bottleneck to progress in research. Image analysis is one way to automate phenotyping, but is challenging as it involves high-dimensional optimisation problems and enormous datasets. Dynamic programming and graph cut are elegant algorithms for finding globally optimal solutions in particular circumstances. I will illustrate and compare these algorithms to estimate animal body composition by segmenting medical images, and plant leaf area by inferring 3D shapes from stereo image pairs.

Theory and practice of withdrawal from stratified reservoirs

Prof. Graeme Hocking
Murdoch University
G.Hocking@murdoch.edu.au

2:20 pm Monday

Water contained in storage reservoirs in temperate climates is stratified in density for most of the year due to variations in temperature and salinity. When water is withdrawn for irrigation, town supply and reservoir management its origin depends on a number of factors. This problem has been of interest since the early 1900s and the first papers on the practical application appeared in the late 1940s. This was followed by a period of intense research activity involving both experimental and theoretical work that provided an outline of the general behaviour of such flows, but as always threw up a number of further questions. The details for nonlinear stratifications were difficult to obtain and so in most cases a linear approximation was used for 'real' modelling of lakes and reservoirs. Fast computers and better algorithms now allow a much more accurate representation of these flows including nonlinearity and complicated geometries.

A history of the understanding of this problem and the techniques employed to study it will be given along with the most recent developments.

Is Mother Nature shortsighted? Evolutionary processes do not maximize population performance

Prof. Hanna Kokko
The Australian National University
hanna.kokko@anu.edu.au

9:00 am Wednesday

Popular accounts of evolution typically create an expectation that populations become ever better adapted over time, and some formal treatments of evolutionary processes suggest this too. However, such analyses do not highlight the fact that competition with conspecifics has negative population-level consequences too, particularly when individuals invest in success in zero-sum games. My own work is at the interface of theoretical biology and empirical data, and I will discuss several examples where an adaptive evolutionary process leads to something that appears silly from the population point of view, including a heightened risk of extinction in the Gouldian finch, reduced productivity of species in which males do not participate in parental care, and deterministic extinction of local populations in systems that feature sexual parasitism.

Geofizz Unfazed

Prof. Robert McKibbin
Centre for Mathematics in Industry
Massey University
R.McKibbin@massey.ac.nz

9:00 am Thursday

Most geophysical systems are multi-component, multi-phase structures. When the components and phases are quantitatively modelled as interacting volume-averaged continua, the application of mechanical and thermodynamical laws usually give rise to non-linear systems of pde's. Rarely are the geophysical systems in steady state, and even when modelled as such, contain busy processes that mix and spread the components and attributes in a locally-chaotic non-reversible way that is variously termed either diffusion or dispersion, and which comprises both molecular diffusion and advection-dispersion mechanisms. Typically, the locally-averaged dispersive transport is assumed to follow a Fick's-type law, where the flux is in the direction of the negative concentration gradient. The relative importance of the relevant diffusive and advective-dispersive mechanisms depends on the length- and time-scales involved; the views range from microscopic to very large-scale.

Here, some of these phenomena are illustrated using simplified models for a variety of dispersive processes: where solids move in fluids (particle transport in the atmosphere or water), solids and fluids move in fluids (hydrothermal and volcanic eruptions), fluids move in fluids (gas and droplet dispersion in air) and fluids move in solids (flow in porous media). I will explain why simplified models are useful, and look to applications in volcanic eruption plumes and tephra-fall, agricultural spray drift, and thermal convection and pollution transport in groundwater aquifers. (With coloured pictures.)

2012 ANZIAM Medallist

Over the past two decades, Robert has been one of the pre-eminent applied mathematicians in New Zealand, with a particular focus on geophysical, geothermal and industrial applications. His mathematical work ranges from geothermal fluid dynamics and hydrothermal eruptions, to the modelling of ground subsidence and aluminium smelting cells. He is highly regarded for his early work in the 1980s in hydrothermal eruptions that appeared in the Journal of Geophysical Research, and presented in a way that made his research accessible to practitioners. His work has attracted significant funding, and national and international recognition through numerous invitations to speak at international applied mathematics conferences.

There are few other applied mathematicians in New Zealand who have shown more devotion and service to the field than has Robert. Through his enthusiasm, energy, and sustained achievement, he has demonstrated a life long commitment to the applied and industrial mathematics profession, to the extent that he well and truly meets the criteria for this award. The selection panel unanimously recommends that Professor Robert McKibbin be awarded the ANZIAM Medal for 2012.

Collective cell behaviour with clustering

Dr Matthew Simpson
School of Mathematics
Queensland University of Technology
matthew.simpson@qut.edu.au

2:10 pm Wednesday

Classic differential equationbased models of collective cell behaviour, such as the logistic growth model, invoke a mean-field assumption which is equivalent to assuming that individual cells in a discrete representation of the model interact with each other in proportion to the average population density. Mean-field models imply that the dynamics of the system are unaffected by spatial structure, such as the formation of patchiness or clustering within the population. This limitation is of concern since experimental observations show that cells form spontaneous clusters under a range of conditions suggesting that standard models might be inappropriate for describing these systems.

Recent developments have introduced a class of models, known as moment dynamics models, which account for the dynamics of individuals, pairs of individuals, triplets of individuals, and so on in the discrete formulation of the process. Such models enable us to describe the dynamics of populations with clustering effects; however, little progress has been made with regard to applying moment dynamics models to experimental data. Inspired by experimental observations, we will use stochastic simulations to demonstrate the failure of the mean-field assumption and outline how moment dynamics models allow us to make useful predictions of clustered populations. We also present new experimental results describing the formation of a monolayer of cells using two different cell types: 3T3 fibroblast cells and MDA MB 231 breast cancer cells. A visual and statistical analysis indicates that the 3T3 monolayer forms without clustering whereas the 231 monolayer formation is associated with significant clustering. Calibrating mean-field model and a moment dynamics model to both data sets shows that care ought to be exercised when implementing standard mean-field models. We conclude by briefly discussing the implications of cell clustering in the context of impaired wound healing.

2012 J.H. Michell Medallist

Matthew obtained a Bachelor of Engineering degree from the University of Newcastle in 1998 and a PhD from the University of Western Australia in 2003. Between 2003 and 2010 he was a Research Fellow and then Australian Postdoctoral Fellow at the University of Melbourne. Having been awarded an ARC Postdoctoral Fellowship in 2006, Matthew then worked with Professors Kerry Landman and Barry Hughes to develop new mathematical tools that describe multiscale data from cell biology experiments. Since his appointment at QUT Matthew has established strong collaborative links with both mathematicians and life scientists. He has published around 40 papers, many of which have been well-cited.

Since 2010 he has been a Lecturer and then Senior Lecturer at the Queensland University of Technology. Matthew has obtained significant research funding, supervised a number of students, and presented results at ANZIAM meetings since 2004. The committee regards him as a worthy recipient of the 2012 J.H. Michell Medal.

9 Contributed Abstracts

Abstracts are ordered by the author's last name.

Modelling induced resistance to plant disease using dynamical systems

Miss Nurul Syaza Abdul Latif†, G. C. Wake, T. Reglinski and P. Elmer
Institute of Information and Mathematical Sciences
Massey University
n.s.abdullatif@massey.ac.nz
3:20 pm Monday

Plant disease control has traditionally relied heavily on the use of agrochemicals noxious to the environment. An alternative strategy is that of induced resistance (IR). However, whilst IR has proven effective in controlled environments, it has shown highly variable field efficacy which raises questions about its potential for disease management of a given crop.

The mathematical modelling of IR assists with understanding the dynamics of the phenomenon in a given plant cohort against a selected disease-causing pathogen. Here, a prototype mathematical model of IR promoted by an elicitor is proposed and analysed. Susceptible plants (S) may become Diseased (D) upon exposure to a compatible pathogen or are able to become Resistant (R) via basal defence mechanisms. The application of an elicitor enhances the basal defence response thereby affecting the relative proportion of plants in each compartment. The IR response is modelled using a forward-and-backward kinetics framework to describe the dynamics of the compartments. The terms in the equations are identified using established principles governing disease transmission and this introduces parameters which are determined by matching data to the model using computer-based algorithms. These then give the best match of the model with experimental data.

A case study of IR will be given to illustrate the system. Results include the model predicts the relative proportion of plants in each compartment and quantitatively estimates elicitor effectiveness. However, the model is generic and will be applicable for a range of plant-pathogen-elicitor scenarios.

Equilibria and Optimisation: An interesting approach from the study of selfish networks

Mr Giles David Adams†, Prof. Peter Taylor, Dr. Mark Fackrell
Department of Mathematics and Statistics
University of Melbourne
gilesdavidadams@gmail.com
12:40 pm Monday

We are interested in studying flows in a network where users choose their path in such a way that their individual cost is minimised. Commuter traffic is a common application.

Here arises the notion of a Wardrop Equilibrium: a distribution of flows along the paths in the network such that no user can change their choice of path and make a saving in cost.

It has been shown that equilibria for a given network are unique up to certain equivalences, and this was done in an interesting way: by constructing an associated optimisation problem where the conditions of the equilibrium fell out in the unique optimal solution.

In my talk I will give a brief outline of some of the key ideas of Selfish Networks and describe the interesting optimisation approach as above.

Modelling rainfall on various time scales

Sherin Ahamed†
School of Computing and Mathematics
The University of South Australia
sherin.ahamed@mymail.unisa.edu.au
2:40 pm Wednesday

Many hydraulic models need daily, monthly and seasonal rainfall data as inputs. Often to test the robustness of the model, several realizations of the data are required. Synthetically simulated values have many realizations for which each has equal probability of occurrence as the observed ones. We generate seasonal, monthly and daily rainfall data that matches the first two statistical moments of the observed data. The problem in this field is that the models developed at the different time scales are inconsistent. We show that our modelling structure ensures that, for instance, models for daily rainfall give the correct statistics on a monthly scale. For these simulations, we use the rainfall data from Hume meteorological station located in New South Wales.

Feedback control for reaction-diffusion-delay equations: semi-analytical solutions

Mr Muteb Alharthi†, Professor: Timothy Marchant, Associate Professor: Mark Nelson
maths
university of wollongong
mraah761@uowmail.edu.au
4:40 pm Monday

Semi-analytical solutions for autocatalytic reactions with mixed quadratic and cubic terms, are considered. The model is coupled with diffusion and considered in a one-dimensional reactor. Feedback control via varying the boundray concentrations is considered. The Galerkin method is used to approximate the spatial structure of the reactant and autocatalyst concentrations. Delay ordinary differential equations are then obtained as an approximation to the governing equations and analyzed to obtain semi-analytical results for the reaction-diffusion cell. The region of parameter space, in which Hopf bifurcations can occur, is found by a local stability analysis of the semianalytical model. The effect of varying the delay feedback parameters, the relative importance of quadratic and cubic reaction terms and diffusion of the two species are examined in detail. The usefulness and accuracy of the semi-analytical results are confirmed by comparison with numerical solutions of the governing delay partial differential equations.

Corneal Epithelium Wound Healing

Mr Fehaid Alshammari†
Mathematical Science
Queensland University of Technology
fashmmri@yahoo.com
3:20 pm Wednesday

The human cornea is a tissue of deceptively simple structure, yet the cellular and physical processes that affect its development and importantly its repair, are complex and of considerable experimental interest. The maintenance of a healthy transparent cornea depends upon regulation of fluid, nutrient and oxygen transport through the tissue, together with the recruitment of stem cells from the limbus that differentiate and migrate to repair damage associated with disease, physical injury or surgery. Experimental studies designed to identify and characterise the processes of tissue maintenance and the biomechanical properties of the cornea, include the construction of in vitro models of corneal cells in tissue-engineered constructs.

All existing relevant mathematical models do not cover all the physical processes that play a role in the development, maintenance, growth and repair of the cornea.

In this speech we are highlighting a modelling framework that is capable of capturing cell kinetic data, such as that presented by Sandvig et al. and that its solutions evolve to traveling waves of speeds that comparable to those determined

experimentally.

Modelling Microbial Growth in a Closed Environment

Bob (Robert) Anderssen, Maureen Edwards, Ulrike Schuman
Mathematics, Informatics and Statistics
CSIRO
Bob.Anderssen@csiro.au
10:40 am Wednesday

The modelling of microbial (fugal, bacterial) growth depends not only on the environment in which the growth is occurring but also on the type of measurements used to record the growth. When growth is occurring in an open environment and is measured as the time evolution of the total number of microbes, alive and dead, autonomous ordinary differential equation (ODE) models are appropriate. For growth in a closed environment, which is indicative of the situation in planned short-term experiments, autonomous ODE models do not necessarily capture the dynamics under investigation. This in part relates to the fact that, in an autonomous model, the total population is modelled as a self-limiting process (with no deaths). Closed environment situations arise when the question under examination relates to the activity of the surviving microbes, such as occurs in the spoilage and contamination of food, the gene silencing activity of fungi or the production of a chemical compound by microbes. Practical and theoretical implications associated with the measurement and modelling of the number of surviving fungi (or bacteria) in a closed environement will be discussed. The limitations of current measurement protocols to track the number of surviving fungi (or bacteria) will be mentioned. The use of non-autonomous modifications of autonomous ODE models of growth will be proposed and analysed.

Finite-time blow-up of one- and two- dimensional Stefan problems

Mr Julian Back†
QUT
j.back@student.qut.edu.au
12:20 pm Tuesday

The classical Stefan problem has long been used to model melting processes, for example, the melting of a ball of ice. Recently, there has been work done to alter this model by modifying the prescribed melting temperature condition on the phase boundary, such as including surface tension via the GibbsThomson effect to obtain results relevant to micro- or nano-sized particles. However, the addition of surface tension leads to physically unrealistic results, such as finite-time blow-up, which is unexpected. Regularising this unphysical behaviour by incorporating extra physics into the problem is discussed for one- and two-dimensional Stefan problems.

Consistent Modelling of VIX and Equity Derivatives Using a 3/2 Plus Jumps Model

Mr Alex Badran†, Jan Baldeaux
University of Sydney
University of Sydney
alexjbadran@gmail.com
5:20 pm Monday

In this talk quasi-closed-form solutions are derived for the price of equity and VIX derivatives under the assumption that the underlying follows a 3/2 process with jumps in the index. The newly-found formulae allow for an empirical analysis to be performed. In the case of the pure-diffusion 3/2 model, the dynamics are rich enough to capture the observed upward-sloping implied-volatility skew in VIX options. This observation contradicts a common perception in the literature that jumps are required for the consistent modelling of equity and VIX derivatives. We find that the 3/2 plus jumps model is more parsimonious than competing models from its class; it is able to accurately capture the joint dynamics of equity and VIX derivatives, without sacrificing analytic tractability. The model produces a good short-term fit to the implied volatility of index options due to the richer dynamics, while retaining the analytic tractability of its pure-diffusion counterpart.

Stable Processes with Boundary Constraints and Fractional Cauchy Problems

Dr Boris Baeumer, Mihály Kovács, Harish Sankaranarayanan
Department of Mathematics and Statistics
University of Otago
bbaeumer@maths.otago.ac.nz
10:20 am Tuesday

A stable process is a jump process with a heavy tailed jump distribution. On a bounded domain different types of boundary events (such as killing, reflecting, or dropping) can be imposed. We give the forward and backward governing equations of the process for various boundary conditions. Wellposedness and solutions are given via a stochastic interpretation of the numerical Grunwald approximation.

Health benefits: Do they add up?

Prof. Nigel Bean, S. Fitzgerald
School of Mathematical Sciences
University of Adelaide
nigel.bean@adelaide.edu.au
5:00 pm Monday

Clinical trials are the way in which modern medical systems test whether individual treatments are worthwhile. Sophisticated statistics is used to try and make the conclusions from clinical trials as meaningful as possible.

What can a very simple probability model then tell us about the benefit of multiple treatments? What might the implications of this be for the whole health system?

This talk is based on research currently being conducted with a physician at a major Adelaide hospital. It requires no health knowledge.

Coarse-graining and simplification of bursting dynamics

Dr Alona Ben-Tal, Ioannis Kevrekidis, Joshua Duley
INMS
Massey University
a.ben-tal@massey.ac.nz
11:00 am Thursday

A system of bursting neurons often exhibits complex dynamics which consist of multiple states and chaotic behaviour. However, in certain applications, the exact details of this dynamics may not be important and one would like to use a simplified model that captures the dynamics roughly. We have developed a numerical method that maps between the variables of a bursting neural network (for which the equations are known) and the variables of a simplified model (for which the equations are unknown). By simulating the neural network for short periods of time we can estimate the dynamics the simplified model should retain and gain a better understanding of the restrictions on the parameters domain for which the simplification is valid.

Group theoretic formalization of double-cut-and-join model of chromosomal rearrangement

Ms Sangeeta Bhatia†
School of Computing, Engineering and Mathematics
University of Western Sydney
sangeetabhatia03@gmail.com
3:40 pm Wednesday

Analysis of genome rearrangements is an important problem in determining phylogenies. Various combinatorial and graph theoretic models have been used to model the different rearrangement events such as inversion of fragments of genome, translocation of a section etc. One such model "Double Cut and Join" has received attention recently. In this talk, I'll present our work of reformulating the double cut and join model in a group theoretic framework. Use of group theoretic models in the field of phylogenetics hold immense promise. I'll describe how group theoretic models may be more extensible and easily able to accomodate biological constraints.

Mathematical Modelling of Cell Invasion

Miss Rachelle Binny†
Mathematics and Statistics
University of Canterbury
rachelle.binny@pg.canterbury.ac.nz
3:00 pm Wednesday

Discrete, stochastic models are often employed to describe the behaviour of individual invading cells, incorporating events such as cell migration and proliferation. In such models, migration is often restricted to a lattice, with pre-defined grid spaces and a fixed carrying capacity. However, recently-developed lattice-free models, where cells are not restricted to discrete lattice sites but can wander freely across a continuous domain, have been shown to result in a more realistic configuration of cells. Continuum models can provide insight into population-level cell dynamics. Linking these two approaches to produce a multi-scale model of cell invasion has been a key focus of recent research.

We aim to develop such a model, based on a lattice-free modelling framework, which incorporates local cues governing individual cell behaviour and relates these microscopic mechanisms to the emergent behaviour of the invading cell population. Using our model in conjunction with experimental data will enable us to predict clinically relevant outcomes and to test the efficacy of current therapeutic strategies.

Mixing times in evolutionary game dynamics

Dr Andrew Black, Arne Traulsen, Tobias Galla
Mathematical Sciences
University of Adelaide
andrew.black@adelaide.edu.au
12:20 pm Wednesday

Evolutionary game theory is a framework for studying the evolutionary dynamics of traits or strategies within a large population of agents. The fitness of any given strategy is typically frequency dependent, which means its success depends on the relative abundance of other strategies within the population.

Without mutation or migration, the evolutionary dynamics lead to the extinction of all but one strategy–a process which has been well studied by calculating fixation times. However, many biological arguments focus on stationary distributions in a mutation-selection equilibrium. For these problems the mixing time is an important quantity; this is the time for the probability density to reach stationarity.

We study a simple evolutionary game in a finite population which can be modeled by a Markov process. Using a WKB approximation of the master equation we show how the problem of calculating the mixing time can be turned into one of classical mechanics and optimizing a Hamilton-Jacobi equation.

Introduction to Computer Aided Assessment of Advanced Questions using MapleTA

Prof. Bill Blyth, Dr Asim Ghous
Mathematics
RMIT University and ASES
bill.blyth@rmit.edu.au
11:40 am Thursday

MapleTA is the major Computer Aided Assessment, CAA, system for courses using mathematics. Version 8 has very many features, for details and a recorded webinar, see http://www.maplesoft.com. Invisible to the student, MapleTA uses Maple as its Computer Algebra System, CAS. MapleTA keeps full records of student results and communicates directly with most Learning Management Systems, such as Black Board and Moodle. The use of MapleTA for routine question types such as those found with many drill and practice assignments is widespread. There are large collections of Questions that are available for free download and use, for example: from the University of Guelph (Canada), there are full modules of MapleTA questions for practice and sample tests (and Maple files used for teaching) for first year Calculus I and II. We illustrate how to author some advanced questions asking students for open responses (such as Chris Sangwins Give an example of an odd function and a related parameterized question) as well as questions using Maple plots which are more advanced than usually seen in MapleTA. This includes the design of a MapleTA question for the traditional first year calculus Norman Window problem using a parameter (to individualize the question) and including a diagram (generated by Maple, within MapleTA). Universities in many countries have decreasing staff/student ratios. First year courses, in particular, have large enrolments so MapleTA (the only commercially available CAS-enabled CAA) has much to offer staff in managing their marking load

Statistical Analysis in Energy Meteorology

Prof. John Boland
ITMS
University of South Australia
john.boland@unisa.edu.au
5:00 pm Wednesday

I will present a survey of the statistical tools I and my team have employed in evaluating the performance of energy systems subject to the influence of climate variables. It will include the following topics: 1. Probabilistic forecasting of solar radiation time series at hourly and intra hourly time scales. This will include work from a 2013 paper in Solar Energy on this topic. We use a combination of Fourier series, Box-Jenkins and dynamical systems approaches to construct the forecasting tool. This was developed as part of an Australian Solar Institute grant and will be part of the Australian Solar Energy Forecasting System (ASEFS) being developed under a second grant. 2. Estimation and forecasting of wind farm output volatility. We estimate the volatility of wind farm output at five minute and half hour time scales, using a version of realised volatility we have developed using ten second data. This has been published in Environmental Modeling and Assessment. 3. The Boland Ridley Lauret (BRL) model for estimating diffuse solar radiation from global radiation will be discussed. This is one of two models, and the only statistical one, used in Meteonorm software. It is reported in various papers in Renewable Energy and elsewhere.

On the Augmented Lagrangian Dual for Integer Programming

Prof. Natashia Boland, Andrew Eberhard, Jeff Linderoth
The University of Newcastle
natashia77@gmail.com
12:00 pm Thursday

Whilst many dual problems for integer programming are known, there has been very little exploration of truly dual algorithms for integer programming. This is in contrast to linear programming, in which duality has been vigorously exploited algorithmically. The augmented Lagrangian dual is well known in convex optimization, in which arena it has effective solution algorithms. Here we consider the augmented Lagrangian dual for integer programming a highly nonconvex problem. We discuss a new primal characterization of this dual that provides some insights about its behaviour, and from which it can be proved that the dual has zero gap, i.e. the value of the dual is precisely the value of the original integer program. Some preliminary numerical results showing how practically efficient approaches to the augmented Lagrangian relaxation can yield better bounds than the standard Lagrangian relaxation will be presented.

The Bernoulli Equation in PDE form modelling Interfacial Fluid Flows

Dr Michael Brideson, Larry Forbes
School of Mathematics and Physics
University of Tasmania
michael.brideson@utas.edu.au
12:40 pm Monday

We consider two inviscid, immiscible, and incompressible fluids separated by a sharp interface. The outer fluid flows in a so-called straining pattern about the inner fluid, which contains a source. When the inner fluid exhibits cylindrical symmetry (line source) or spherical symmetry (point source), the shape of the interface is described by a non-linear first order PDE. For both geometries the PDE resembles the famous non-linear first order ODE, the Bernoulli Equation. Remarkably, the power law variable substitution technique used in the single variable case is also effective in this multi-variable case, and allows us to obtain closed-form solutions to these nonlinear PDEs. The examples presented may have applications in astrophysics.

Ponding Time Under Irrigation: Where Approximate Becomes Exact

Prof. Phil Broadbridge
School of Eng and Math Sciences
La Trobe University
P.Broadbridge@latrobe.edu.au
12:20 pm Thursday

The Darcy-Buckingham macroscopic approach to soil-water modelling, leading to a nonlinear Richards diffusion-convection equation, has been very useful for many decades. Since the 1980s, several groups have used an integrable one-dimensional version of Richards equation, with realistic nonlinear transport coefficients, to predict experimentally verifiable quantities. Neat expressions have been derived for time to incipient ponding, for the dependence of sorptivity on pond depth and for the second and higher infiltration coefficients. A number of practical predictions of the integrable model agree exactly with those of the approximate analytic method originated earlier by Parlange, involving approximations within an integrand after expressing the water conservation equation in integral form.

An Integer Programming Approach to Picking Items for Experimental Sets

Ms Rachel Bunder†, Natashia Boland, Andrew Heathcote
Mathematical and Physical Sciences
University of Newcastle
rachelbunder@gmail.com
3:00 pm Wednesday

Psychologists and other experiment designers are often faced with the task of creating sets of items to be used in factorial experiments. These sets need to be as similar as possible to each other in terms of the items' given attributes. We will explore what "similar" means and how integer programming compares to current approaches.

The Exact Penalty Map for Nonsmooth Optimization

A/Prof. Regina Burachik, Regina S. Burachik, Alfredo N. Iusem, Jefferson G. Melo
School of Mathematics and Statistics
University of South Australia
regina.burachik@unisa.edu.au
3:40 pm Wednesday

Augmented Lagrangian duality provides zero duality gap and saddle point properties for nonconvex optimization. On the basis of this duality, subgradient-like methods can be applied to the (convex) dual of the original problem. These methods usually recover the optimal value of the problem, but may fail to provide a primal solution. We prove that the recovery of a primal solution by such methods can be characterized in terms of (i) the differentiability properties of the dual function, and (ii) the exact penalty properties of the primal-dual pair. We also connect the property of finite termination with exact penalty properties of the dual pair. In order to establish these facts, we associate the primal-dual pair to a penalty map. This map, which we introduce here, turns out to be a convex and globally Lipschitz function, and its epigraph encapsulates information on both primal and dual solution sets.

3D modelling of suspended sediment transport in turbulent open channel fluids

Mr Meng Cao†, Meng Cao and A. J. Roberts
Mathematical School of Adelaide University
meng.cao@adelaide.edu.au
12:20 pm Monday

A 3D model of suspended sediment concentration is proposed in open channels. We explore the implications of changing the theoret- ical base to the turbulent Smagorinski large eddy closure. Depth- averaging flow equations is avoided. Centre manifold theory supports the existence of a slow manifold in the system. Computer algebra constructs the slow manifold in terms of the sediment concentration, the fluid depth, the mean lateral velocities and the falling velocity of particles. The model incorporates the effects of enhanced effective convection and dissipation with minimal assumptions. In the appli- cations of more complex situations, researchers can systematically include more complex physical processes via the resultant model.

Extensional acoustic vibrations of axisymmetric nanoparticles immersed in viscous fluids

Dr Debadi Chakraborty, Debadi Chakraborty,1 Matthew Pelton,2 and John E. Sader1,* 1Department of Mathematics and Statistics, University of Melbourne, Parkville, 3052, Victoria, Australia 2Center for Nanoscale Materials, Argonne National Laboratory, Argonne, Illinois 60439, USA
Research Fellow at the Department of Mathematics and Statistics
The University of Melbourne
debadi.chakraborty@unimelb.edu.au
1:00 pm Tuesday

The acoustic vibration of nanoparticles immersed in viscous fluid has been studied recently using ultrafast laser spectroscopy and analytical theory. These reports have provided fundamental insight into damping mechanisms both intrinsic and extrinsic to the material. In this talk, we extend this analytical theory and present a comprehensive numerical analysis of the extensional mode vibrational response of axisymmetric nanoparticles immersed in viscous fluids. This is achieved using finite element solutions to the fluid-structure problem coupled with a rigorous scaling analysis. Our investigation yields results of a general nature that can be applied to nanoparticles of arbitrary composition and size immersed in viscous fluid. Right circular, conical, and bipyramidal axisymmetric cylinder geometries are considered. Comparison to available measurements is provided and a discussion of the interpretation of such measurements is presented. The results of this study thus facilitate experimental investigations of nanomaterial energy dissipation in fluid.

Mathematical Modelling of Atherosclerosis: A disease of boundary conditions

Mr Alexander Chalmers†, Mary R. Myerscough
The School of Mathematics and Statistics
The University Of Sydney
acha5264@uni.sydney.edu.au
4:40 pm Monday

Atherosclerosis, remains as the main cause of death in the world, despite changes in pharmacological approaches. In atherosclerosis, the arterial lining undergoes a sequence of specific inflammatory responses to an injury to the lining of the blood vessel and permeating lipids from the blood stream. We model these events that occur immediately after the injury. The model includes processes that happen at the endothelium which, mathematically, are formulated as boundary conditions, and processes that take place inside the blood vessel wall. Through this mathematical modelling, we gain an understanding both of the initial inflammatory phase that follows immediately after injury and of the longer timescale, quasi static process of plaque development inside the arterial wall. We will show results as to how different low density lipoprotein (LDL) levels and immune responses can affect to the development of a plaque. In particular we show, that changes in immune response when blood LDL levels are high can lead to dramatic increases in the rate of lipid accumulation due to a saddle-node bifurcation.

Optimising Order Batching

Mr Hadi Charkhgard†, Martin Savelsbergh
School of Mathematical and Physical Sciences
The University of Newcastle
h.charkhgard@gmail.com
12:40 pm Wednesday

Companies around the world are looking for ways to cut costs and improve productivity within their warehouses. The process of retrieving articles from their storage locations in order to satisfy customer demand is the most labor-intensive and costly activity in a warehouse. Consequently, improving the order picking process not only decreases costs, but it also increases productivity and customers' satisfaction. To improve order picking efficiency, order batching can be used. Order batching is a method of clustering orders into pick groups, and picking the orders in a pick group on a single pick tour through the warehouse. Whereas most research has focused on minimising the travel time of a pick tour, our research focuses on simultaneously minimising the travel time and the pick time of a pick tour. Moreover, instead of using a simple routing strategy, such as the S-shape routing strategy, we employ a near optimal routing strategy. We have implemented an efficient and effective GRASP algorithm for order batching. Finally, we developed a lower bounding methodology to be able to provide an assessment of the quality of the solutions produced by the GRASP algorithm. A computational study shows the GRASP algorithm produces solutions that are guaranteed to be within 6.5 % of optimality for instances of up to 1000 orders, 2000 products, and 50 aisles.

On issues concerning the assessment of information contained in aggregate data using the F-test

Mr Salman Cheema†, Beh, E.J., Hudson, I.L.
Mathematical and Physical Sciences
Univeristy of Newcastle
c3155404@uon.edu.au
3:20 pm Wednesday

The analysis of aggregate data has received increasing attention in the statistical discipline over the last decade. Much research has been done on the estimation of cell values of a 2x2 table given the marginal totals; the results from their analysis have received mixed reviews. More recently the focus has been shifted toward analyzing the overall association structure rather than estimating the cells. This presentation provides some insight into how informative aggregate data is, in single 2x2 contingency table, with missing or unknown cell values. The information in the margins of 2x2 table has been quantified by using the squared deviation of the expected cell values over the range of the corresponding cell values, where the rows and columns totals are known. We have presented some possible test statistics to assess the statistical significance of the information in aggregate data. Some related to these test statistics are also discussed.

Multiscale modelling of diffusion in a material with microstructures

Mr Chen Chen†
School of Mathematical Sciences
The University of Adelaide
chen.chen.adl@gmail.com
1:00 pm Monday

Modern materials With microscale ine structures are effectively impossible to simulate over macroscales via a microscale simulator, even With the most advanced technology. Through multi-scale dynamical system modelling, We aim to develop techniques to simulate such previously inaccessible problems in a fast and inexpensive way. I plan to discuss the macroscale modelling of a one-dimensional inhomogeneous diflsion on a lattice with two-periodic diffusivity. This pilot study effectively homogenizes microscale Varying diffusivity. I compare a centre manifold approach With that of homogenization theory. Both approaches result in the classic leading order model of diffusion. I also plan to propose suitable boundary conditions for the multi-scale model corresponding to the Dirichlet boundary conditions on the original system. Numerical method also verifies the validity of the multi-scale techniques. The modelling techniques are expected to adapt to higher dimensions and more complicated boundary conditions. An application of this research is to model materials with more complicated structures such as metamaterials Where cells are arranged in periodic patterns microscopically. Extraordinary properties of metamaterials include negative or low values of permittivity, permeability and refractive index, which are rarely available from conventional materials.

Motion of a clean bubble past a surface

Sue Ann Chen†
Department of Mathematics and Statistics
University of Melbourne
sue.chen87@gmail.com
4:00 pm Monday

The motion of a bubble moving with a lateral velocity past a surface has been explored recently by White and Carnie. At sufficiently high velocities where purely hydrodynamic treatments are applicable, the hydrodynamic pressure present within the film dominates the disjoining pressure while at very low velocities, the first effects of fluid flow due to perturbation to the equilibrium between surface forces and surface tension are observed. White and Carnie investigated the ‘zeroth-order theory’ of steady tangential motion of a bubble, assumed to be surfactant-free. The effect of incorporating disjoining pressure in the steady drag beyond leading order in the sliding velocity will be considered.

Mathematical and Computational Modelling for the Phenotypic Analysis of Cereal Plants

Mr Josh Chopin†, Prof. Stan Miklavcic, Dr. Hamid laga
Phenomics and Bioinformatics Research Centre
University of South Australia
chojp002@mymail.unisa.edu.au
1:00 pm Wednesday

As of 2012, cereal crops account for approximately 50% of global food production, resulting in a worldwide demand for higher yielding grain crops. Applied to plant biology, automated phenotypic analysis based on plant images captured as a function of growth conditions, can help us obtain information on the function of genes and the impact of abiotic stress on plants. However, methods for utilising the vast amounts of information stored in the images of plants are lagging behind the abilities of genomics. Most cereal plant leaves are thin and spindly, which presents a challenge to mathematical and computational segmentation techniques. In this talk I will discuss techniques for the segmentation and representation of plants in images using Level Set Methods and Active Contours, outlining the key aspects of my PhD.

Symmetric solutions to the forced extended Korteweg-de Vries equation

Dr Simon Clarke, Bernard Ee
Mathematical Sciences
Monash University
simon.clarke@monash.edu
3:00 pm Wednesday

We consider steady symmetric solutions to the forced extended KdV equation exactly at linear resonance, as an extension to the spectrum of symmetric solutions of the forced KdV equation. A parametric relationship in terms of the quadratic and cubic nonlinearity is obtained numerically and the linear and nonlinear stability of the resulting single and double humped solitary wave solutions are analysed. For single humped solutions the primary form of instability is the generation of an upstream propagating solitary wave and downstream propagating shelf, as for the fKdV equation. For the double humped solutions two types of primary instability occur: a similar instability to the single humped solutions, and downstream propagating disturbances, creating a quasi–periodic asymptotic solutions. Examples of both solutions and transition solutions will be presented.

Large-scale atmospheric vortices

Mr Jason Cosgrove†, Prof. L. K. Forbes
School of Mathematics and Physics
University of Tasmania
Jason.Cosgrove@utas.edu.au
10:20 am Monday

The structure of large-scale atmospheric vortices is considered. These are familiar as high or low pressure systems. They can have diameters of hundreds of kilometres, but are typically only about fifteen kilometres high, and so they can be thought of as large flat structures. The air is weakly compressible, and importantly, the Earth is a non-inertial rotating reference frame. That means that high and low pressure systems are subject to the Coriolis pseudo-force, which is the reason that the air rotates about the high or low pressure, rather than simply being drawn directly into it. In the simplest model, known as the f-plane approximation, the Coriolis acceleration is simply assumed to be constant, and this is appropriate to a moderate-sized low (high) pressure system restricted to a given latitude. In the more precise model, known as the β-plane approximation, the Coriolis acceleration is non-constant and varies linearly with latitude.

Initially the pressure system will be perturbed and as time passes the perturbations grown to form wave like fingers. The f-plane and β-plane approximations are in close agreement for mid latitudes but for low latitudes the non-constant Coriolis acceleration has a much greater impact on the formation of the finger structures.

Stokes flows in confined domains

Prof. Darren Crowdy, Darren Crowdy
Mathematics
Imperial College London
d.crowdy@imperial.ac.uk
5:40 pm Monday

This talk will survey mathematical methods for the calculation of slow viscous Stokes flows in two-dimensional confined domains bounded by no-slip walls and/or free surfaces. There has been a resurgence of interest in such problems owing to their application in microfluidics, colloid science, glass fabrication processes and biological fluid mechanics (the dynamics of swimming microorganisms).

Synchronisation and amplitude death in Nanomechanical Oscillators

Mr Peter Cudmore†
School of Mathematics and Physics
The University of Queensland
peter.cudmore@uqconnect.edu.au
4:00 pm Monday

Recent advances in Quantum Engineering facilitate the construction of nano-electromechanical systems (NEMS) in the form of nano-scale resonators embedded in an optical cavity. When externally driven, these systems exhibit "radiation pressure coupling", a weak interaction which can modulate individual resonators amplitude and frequency and cause the entire system to behave collectively.

In the semi-classical limit, such systems can be mathematically modelled as a population of damped harmonic oscillators (nano-scale resonators) which are forced by the cavity. The optical cavity is modelled as a weakly damped harmonic oscillator which is forced and detuned both externally and by each resonator. Because these oscillators are only weekly damped, forced and detuned the model may be reduced to a system of weekly coupled amplitude equations (Ref. 1).

Previous research by Holmes, Meaney and Milburn (Ref. 1) showed that the parameter range of interest has two time scales allowing the separation of slow and fast dynamics. It was also shown that the introduction of a 'mean field' variable, or order parameter akin to the Kuramoto model, allows the reduction to Amplitude Equations which describe the slow change of oscillator phase and amplitude. Systems containing 2 or 3 oscillators were investigated and bifurcation properties of synchronous solutions were found.

Our current research aims to describe in full the amplitude and phase dynamics of these systems for many oscillators. We present some new general results on the existence and stability of amplitude death and synchronous solutions and show that results in the infinite oscillator limit well approximate the finite but large oscillator system. In a physically interesting regime, these results show the stability of synchronisation depends on a simple interaction between the external driving strength and the distribution of oscillator frequencies.

Ref. 1. - C. A. Holmes, C. P. Meaney and G.J. Milburn, *Synchronisation of many nanomechanical resonators coupled via a common cavity field.* Phys. Rev. E **85**, 066203 (2012).

Nongeneric bubble extinction in a Hele–Shaw cell

Mr Michael Dallaston†, Scott W. McCue
School of Mathematical Sciences
Queensland University of Technology
michael.dallaston@qut.edu.au
10:00 am Tuesday

We are interested in the behaviour of a bubble in a Hele–Shaw cell which shrinks due to a fluid source at infinity. Depending on its initial shape, a bubble may contract to a point or pinch off into multiple bubbles. The asymptotic shape of a bubble which shrinks to a point depends on the dynamic condition on the moving interface. Given a constant pressure condition, this extinction shape is generically an ellipse, but there is also a hierarchy of special non-elliptical shapes that arise when the ellipse is degenerate. These special shapes also correspond to borderline behaviour between a bubble shrinking to a point and pinching off.

When surface tension acts on the interface, the generic extinction shape is a circle. Since the curvature of a bubble blows up in the extinction limit, the leading order problem is equivalent (up to rescaling) to unforced, purely surface tension-driven Hele–Shaw flow. A noncircular steady state to this problem can only be achieved when there are flow singularities (sources) on the boundary itself. We discuss numerical and asymptotic solutions in this case.

Continuum modelling and the assumption of homogenous mixing: The importance of being spatially aware

Mr Kale Davies†
School of Mathematical Sciences
University of Adelaide
kale.davies@adelaide.edu.au
4:20 pm Wednesday

When constructing mathematical models for spatial problems, it is often assumed that individual elements in the population mix homogeneously (also known as the law of mass action). Although this assumption allows the development of continuum models, it is often unsound or in some cases completely false. In order to test whether the assumption is valid, we use a hybrid model which connects a cellular automata model to the proposed continuum model. As well as this, we consider the role of diffusion, discussing the possibility of a threshold diffusion coefficient for which the homogenous mixing assumption will hold.

Approximating the Intensity of a Point Process

Dr Frank de Hoog, Bob Anderssen, Adrian Baddeley, Gopal Nair
Mathematics, Informatics and Statistics
CSIRO
Frank.deHoog@csiro.au
5:20 pm Wednesday

The integral equation examined here arises in the approximation of the intensity of spatial point processes such as arise in the modelling of the statistical physics of molecular gases and in spatial statistics. In statistical physics, the points represent the locations of the individual molecules in a gas, and the point process is a stochastic model of the fine-scale behaviour of the gas. In spatial statistics, the points may represent the observed locations of trees, road accidents, bird nests, crystal impurities and so on, and the corresponding point process is a statistical model of the interrelationship between these locations.

The intensity of a point process is the expected ('average') number of points per unit volume. For the problems of interest, corresponding to pair-wise interaction Gibbs point processes, the intensity function can be approximated by a spatially-varying function$f(x)$, which satisfies the non-linear integral equation

$$f(x) = g(x) \exp\left(-\int_D c(x-y) f(y)\, dy \right), \, x \in D$$

This talk examines an under relaxation iterative techniques for the numerical solution of this equation.

The Ellipsing Pendulum

Dr Michael Deakin
School of Mathematical Sciences
Monash
michael.deakin@monash.edu
10:00 am Thursday

The motion of a pendulum executing small oscillations about its position of stable equilibrium is examined. This motion is canvassed in many introductory mechanics texts, but its true complexity is rarely addressed. In the simplest of approximations, the bob executes simple harmonic motion and traces out an elliptical path. However, more precise analysis demonstrates that this ellipse actually precesses in the direction along which the motion proceeds. A derivation of the formula giving the rate of this precession is presented here. It would seem to be new and moreover is simpler than previous derivations. It uses dimensional analysis and completes the calculation by deducing a general formula from two

special cases. It thus provides an illustration of the power of dimensional analysis, and also offers a simpler entre into a classical (if often oversimplified) aspect of applied mathematics.

Unstable Klein-Gordon Modes in an accelerating universe

Kathryn Deutscher†
Mathematics and Statistics
La Trobe University
krdeutscher@students.latrobe.edu.au
5:40 pm Monday

Current observations show the universe to be made up predominantly of dark energy, (energy that has no particle or radiation interpretation). It is known that when unstable modes are quantised, there is no Fock representation and therefore no particle or radiation interpretation. In this sense, these modes might be regarded as dark energy.

We develop a full solution of a scalar quantum field coupled to an accelerating universe. In the case of minimal coupling of massless fields, there exist modes that become unstable at a discrete sequence of times. After canonical quantisation, these unstable modes represent energy eigenstates that can be viewed as neither particle nor oscillatory radiation. We then partition the energy into stable and unstable components. As time increases, modes of increasing wave number cease to be oscillatory and become unstable. The number of unstable modes remains finite, guaranteeing a preferred physical representation for the system.

Pattern Formation on Networks with Reactions: A Continuous Time Random Walk Approach

Isaac Donnelly†, C. N. Angstmann, B. I. Henry
UNSW
i.donnelly@unsw.edu.au
12:20 pm Monday

Starting with Alan Turing's observations in 1952, our understanding of pattern formation has improved greatly. Initially motivated by biological phenomena, most research has been concerned with patterning, modeled by reaction-diffusion equations, on a continuum (i.e. a 2d manifold corresponding to an animals skin). However on a discrete space such as a network, the continuous diffusion term is not well defined. By assuming that a continuous time random walk models the underlying stochastic process we show that there is an analogous reaction-diffusion equation for the network setting. We also consider a range of patterns on networks and show that some of these are possible without Turing instabilities.

Gradient schemes for diffusion equations

Dr Jerome Droniou
School of Mathematical Sciences
Monash University
jerome.droniou@monash.edu
2:40 pm Wednesday

Carbon storage, oil recovery and nuclear waste disposal are a few of the engineering problems which involve flows in porous media with singular data. In particular, anisotropies and heterogeneites of the medium can be quite strong and, due to their alignment with geological layers, meshes available in practice are usually unstructured and non-conforming.

The past twenty years or so have seen the development of a myriad of numerical schemes for diffusion equations in this constrained engineering framework. Each of these methods came with its own mathematical study of convergence, often involving assumptions which are rarely satisfied in real-world applications.

Gradient Schemes provide a generic framework encompassing many numerical methods and in which, using only a small number of discrete properties, convergence can be obtained for a large class of equations (linear, nonlinear, nonlocal, stationary or transient). These convergence results do not require unphysical assumptions on the data. In particular, minimum regularity is assumed on the solution.

We will present the framework of Gradient Schemes, a few of the methods it encompasses and the generic convergence results it allows to establish.

This is a joint work with R. Eymard, T. Gallouët and R. Herbin

An interpretation of a feasiblity algorithm in Integer programming

Prof. Andrew Eberhard, N. L. Boland, F. Engineer and A. Tsoukalas.
School of Mathematical and Geospatial Sciences
RMIT
andy.eb@rmit.edu.au
10:00 am Thursday

The feasibility pump is a recent, highly successful heuristic for general mixed integer linear programming problems. One can show that the feasibility pump heuristic can be interpreted as a discrete version of the proximal point algorithm. In doing so, we show that feasibility pump algorithms implicitly minimize a weighted combination of the objective and a term which penalizes lack of integrality. This function has many local minima, some of which correspond to feasible integral solutions; the feasibility pump's use of random restarts can be viewed as seeking to escape these local minima when they are not feasible integral solutions and where cycling occurs. This can be more informative than an unstructured project-project interpretation of such interative porcess where integrality is viewed as an l-norm projection and feasibility a Euclidean norm projection. This interpretation suggests alternative ways of incorporating restarts, one of which is the application of cutting planes. Numerical experiments with cutting planes show encouraging results on standard test libraries

Electricity Generation and Transmission Network Design Considering Intermittent Supply

Tarek Elgindy, Simon Dunstall, Melanie Ayre, Luke Reedman, John Ward, Thomas Brinsmead, Paul Graham
CMIS (CSIRO Mathematics, Informatics and Statistics)
CSIRO
tarek.elgindy@csiro.au
10:40 am Thursday

The large-scale deployment of renewable energy generation technologies (such as solar photovoltaic cells and wind turbines) challenges electricity networks due to the typically intermittent nature of energy supply from renewable sources. Our work investigates the transmission network and generation investments that might be required in the medium to long term in order to meet projections of resource use and energy demand that are derived from macro-level economic models. Using time series of plausible future supply and demand, we find periods in the future where the ability of the electricity network to meet supply will be tested, and use these in formulating mixed integer programming models that (at two distinct spatial scales) determine the transmission network and optimum mix of generation investments required to satisfy supply requirements.

Moments of action for diffusion-reaction-advection processes.

Mr Adam Ellery†, Dr Matthew Simpson, Associate Professor Scott McCue, Dr Ruth Baker
Faculty of Science and Technology
QUT
adam.ellery@connect.qut.edu.au
12:40 pm Monday

It is well-known that diffusion-reaction-advection processes take an infinite amount of time to reach steady state. This fact is not very practical if we wish to estimate a finite measure of the amount of time required for a particular process

to reach steady state and it motivates the idea of establishing a finite time, or critical time, after which we can consider a diffusion-reaction-advection processes to be effectively at steady state. Several critical time scales have been proposed over the last twenty years, and almost all carry one of two disadvantages. First, their application requires that we know the full time-dependent solution of the diffusion-reaction-advection equation. Second, their application requires that the analyst make several subjective choices about the definition of critical time. To overcome these limitations we re-examine and extend the concept of mean action time (MAT) that was originally introduced by McNabb and Wake, and later studied by Landman, McGuinness and others. The MAT is advantageous since it provides us with an objective measure of the time taken until the system is effectively steady and can found exactly without requiring the full time dependent solution of the diffusion-reaction-advection equation. We demonstrate a solution methodology to solve for the MAT for a general diffusion-reaction-advection process, and also show that it is possible to solve for higher moments of action, such as the variance, skew and kurtosis of action time, which provides further information about the critical time for diffusion-reaction-advection processes.

Algorithms for Dynamic Quadrilateral-Dominant Tessellation

Mr Darren Engwirda†, David Ivers
School of Mathematics
University of Sydney
d.engwirda@maths.usyd.edu.au
12:40 pm Tuesday

Tessellations are widely used constructs in many areas of computational geometry and numerical analysis, involving the decomposition of a space into disjoint geometrical elements. In this work, we consider the problem of finding optimal, quadrilateral-dominant tessellations for vertex sets in $\mathbf{R}^2$. Specifically, we focus on *dynamic* problems, for which the tessellation must support the insertion and deletion of vertices. Building upon techniques developed for Delaunay triangulations, we present a set of algorithms and geometrical objects for the incremental construction and dynamic maintenance of quadrilateral-dominant tessellations. Our approach is a generalsiation of 'flip-based' Delaunay methods, utilising a catalogue of localised element transformations, or 'flips', designed to improve the local quality of the tessellation. We show that a greedy application of element 'flips' following vertex insertion or deletion operations improves the quality of the tessellation globally, and we discuss the optimality of the resulting structure. We also show that our greedy approach requires only a localised sequence of element 'flips' following an update operation on average, resulting in low algorithmic complexity and efficient practical implementations. We evaluate the experimental performance of our techniques using a set of complex test problems, including data-sets from geo-spatial analysis and mesh generation problems. We assess the performance of our methods in terms of tessellation quality, algorithm run-time and overall storage requirements.

Car Allocation in a Vertical Rotary Car Park

Dr Mark Fackrell, Peter Taylor
Department of Mathematics and Statistics
University of Melbourne
fackrell@unimelb.edu.au
12:20 pm Thursday

Vertical rotary car parks provide a space efficient way of parking cars in a crowded environment. The problem is, however, determining where the cars are to be parked as they arrive. Clearly, if the cars are simply put in adjacent parks, the car park could become unbalanced rather quickly, and engineering for this situation could be quite costly. We set up the car allocation problem as an infinite horizon Markov decision process in order to minimize the imbalance (and to a lesser extent the amount the car park turns), and demonstrate that this approach is superior to some other heuristic methods.

Chebychev-collocation method for non-linear time-stepping problems

Mr David Farmer†, David Ivers
Mathematics and Statistics
University of Sydney
dfar6459@gmail.com
10:00 am Tuesday

Previous work [1] has focused on extending results from [2] for the fourth-order boundary-layer problem $(a^2d^2D^2 - I)(d^2D^2 - I)y = 1$, $y(\pm 1) = y'(\pm 1) = 0$. In our current work we revisit the fourth-order boundary-layer problem, this time with a Chebychev-modal basis applied in a collocation method. Results indicate uniform exponential convergence in d. Although the scaling effect in d is not present (as for the Galerkin approach in [1]) the results, nevertheless, are promising for non-linear time-stepping problems, where use of fast algorithms between spectral and physical space (fast fourier transforms or FFTs) are available. Also, a comparison in the exact errors in the infinity norm for the Galerkin method and Chebychev method are provided, to compare with the theoretical results in [2] for a second order problem.

[1]http://journal.austms.org.au/ojs/index.php/ANZIAMJ/article/view/3950 [2]Schwab, C. (1998). P- and hp- finite element methods. Oxford, Oxford University Press.

Modelling of Large Scale Bagasse Stockpiles

A/Prof. Troy Farrell
Mathematical Sciences
QUT
t.farrell@qut.edu.au
12:40 pm Thursday

A mathematical model for the heat and mass transfer within large-scale bagasse stockpiles is presented, which accounts for a multicomponent gas phase, liquid and vapour water phases and a solid bagasse phase. The model shows good correspondence with experimental data obtained from a “one-dimensional bagasse slab”. The predicted transport dynamics shows that the bulk of a large-scale stockpile becomes anaerobic shortly after construction, however, a narrow shell forms at the outer surface in which oxygen penetration can be sufficient to cause overheating. The model shows that the ground beneath the stockpile acts as a heat sink and the subsequent cooling depends on the size of the stockpile with larger stockpiles remaining hotter than smaller ones. The model predicts that compacted stockpiles are cooler than those with lower compaction because they have lower oxygen levels and a higher thermal conductivity.

Deceptive solutions to singular boundary value problems.

Mr Nicholas Fewster-Young†
School of Mathematics and statistics
UNSW
nicholas@unsw.edu.au
10:00 am Monday

This talk will discuss singular nonlinear boundary value problems where the differential equation may not necessarily be continuous everywhere. There are numerous applications that motivate the study of such problems in the areas of heat and mass transfer, diffusion in a chemical catalytic converter, steady–state oxygen diffusion in a cell with Michaelis–Menten kinetics and in boundary layer theory. The aim of this talk is to present results which yields existence of solutions that focus of these problems.

Reformulations of multiobjective bilevel problems

Prof. Joerg Fliege, Konstantinos Kaparis, Huifu Xu
School of Mathematics
University of Southampton
J.Fliege@soton.ac.uk
11:40 am Thursday

We present new approaches for multiobjective bilevel optimization, derived from an optimality condition for the lower level problem that leads naturally to a nonsmooth equality constraint. The nonsmoothness of the new constraint stems from its derivation as an optimal valuefunction of a particular direction search problem. Preliminary numerical results on bilevel problems occuring in electricity markets show the efficacy of the approach. Further, we consider possible extensions to the multilevel case.

The interaction of convection modes in a box of a porous medium

Mr Brendan Florio†
School of Mathematics and Statistics
University of Western Australia
brendan.florio@graduate.uwa.edu.au
1:00 pm Tuesday

Convection in an infinite layer of porous media occurs if the dimensionless Rayleigh number exceeds a critical value. This is also true for a box of porous media, however, each discrete modal solution has its own associated critical Rayleigh number. Usually just one mode will be generated at the onset of convection, however, there are many critical box dimensions for which up to four modes share the same critical Rayleigh number and all may be generated at the onset of convection. In such circumstances there will be a slow interchange of energy between the preferred modes. A perturbation method is applied to a system where three modes are generated at onset to yield a system of ordinary differential equations which govern the evolution of the amplitudes of the viable modes. Three unique cases arise, each with a different phase-space structure. Critical boxes with "moderate" aspect ratios are are systematically categorised into these cases. While two of the examples represent the usual case where just one mode survives in the final state, the third example is a special case where it is possible for the three modes to coexist. The initial conditions determine which mode(s) will survive. For non-critical boxes, the bifurcations that occur as the Rayleigh number increases are analysed and profiled in the weakly-nonlinear regime.

Solitons in Combustion – A Meeting of Two Old Flames

Prof. Larry Forbes
Mathematics and Physics
University of Tasmania
Larry.Forbes@utas.edu.au
10:00 am Monday

Solitons are famous in water-wave theory, and they traditionally arise as solutions of the Korteweg-de Vries equation. Although they are solutions of a non-linear equation, they nevertheless have properties similar to those of linear waves; they propagate without change of form, and they even interact in such a way that they recover their original shapes after the interaction.

In this talk, we will look at a combustion reaction in a gas. An asymptotic analysis shows that the temperature can form a travelling disturbance that is identical to a classical soliton, even to the point that it has the famous "sech-squared" profile. However, the equation governing the temperature disturbance is not the Korteweg-de Vries equation at all, and as a result, interacting temperature solitons behave in a very different way to their cousins in water-wave theory.

Optimal approximation for nonconvex quadratic optimization

Mr James Foster†, Natashia Boland, Hamish Waterer, Adam Berry
Mathematics
University of Newcastle
james.foster@uon.edu.au
12:20 pm Wednesday

This talk proposes a number of related methods of constructing convex relaxations of low-rank quadratically-constrained quadratic programs. For a fixed allowance on the number of binary variables to be used, these convex mixed-integer linear and quadratic relaxations optimally approximate the original problem, in the sense that the approximating functions have minimal function error to the original constraint functions. We apply our construction to find good global optimization bounds for the optimization of nonconvex electrical power flow problems.

Anti-tumor immunity and growing cancers: a dynamical system approach

Dr Federico Frascoli, Peter Kim (University of Sydney), Barry D. Hughes (University of Melbourne) and Kerry A. Landman (University of Melbourne)
Department of Mathematics and Stastics
Melbourne University
ffrascoli@unimelb.edu.au
10:40 am Wednesday

Preventative vaccination is a method in cancer treatment aimed at stimulating targeted invasions of immune cells, which are capable of destruction of tumor masses. This technique appears to be particularly suitable for the eradication of incipient cancers before clinical detection, and represents a viable alternative to current, more invasive surgical methods.

A coupled system of equations captures the response of a population of immune cells against a growing mass of tumor. Depending on model parameters, a variety of therapeutic scenarios are possible, and the physiological conditions that give rise to different model interactions are discussed. Interestingly, there exist certain conditions under which immune cells fail to eliminate the tumor and oscillatory solutions appear, in which the mass periodically grows and shrinks. Analytical results concerning clinically relevant properties of such solutions are also illustrated, showing methods for optimising immune responses.

Understanding the factors that improve vaccination strategies against tumors is of primary importance in the fight against cancer.

Finite-time entropy: A probabilistic approach for measuring nonlinear stretching in dynamical systems

Gary Froyland, Kathrin Padberg-Gehle (TU Dresden)
Mathematics and Statistics
UNSW
g.froyland@unsw.edu.au
12:00 pm Thursday

Transport and mixing processes in dynamical systems are often difficult to study analytically and therefore a variety of numerical methods have been developed. Finite-time Lyapunov exponents (FTLEs) or related stretching indicators are frequently used as a means to estimate transport barriers. Alternatively, eigenvectors, singular vectors, or Oseledets vectors of numerical transfer operators find almost-invariant sets, finite-time coherent sets, or time-asymptotic coherent sets, respectively, which are minimally dispersed under the dynamics. While these families of approaches (geometric FTLEs and the probabilistic transfer operator) often give compatible results, a formal link is still missing; here we present a small step towards providing a mathematical link. We propose a new entropy-based methodology for estimating finite-time expansive behaviour along trajectories in autonomous and nonautonomous dynamical systems. We introduce the finite-time entropy (FTE) field as a simple and flexible way to capture nonlinear stretching directly from the entropy

growth experienced by a small localised density evolved by the transfer operator. The FTE construction elucidates in a straightforward way the connection between the evolution of probability densities and the local stretching experienced. We develop an extremely simple and numerically efficient method of constructing an estimate of the FTE field. The FTE field is instantaneously calculable from a numerical transfer operator a transition matrix of conditional probabilities that describes a discretised version of the dynamical system; once one has such a transition matrix, the FTE field may be computed for free. We also show (i) how to avoid long time integrations in autonomous and time-periodic systems, (ii) how to perform backward time computations by a fast matrix manipulation rather than backward time integration, and (iii) how to easily employ adaptive methods to focus on high-value FTE regions.

Unified Understanding for Complex Systems and NP-Hard Problems in Computational Mathematics and Sciences

Prof. David Y Gao
University of Ballarat/ANU
d.gao@ballarat.edu.au
10:00 am Monday

One of the fundamental difficulties in complex systems theory and computational science is mainly due to nonconvexity of modeling. In static systems, the nonconvexity usually leads to multi-solutions in the related governing equations. Each of these solutions represents certain possible state of the system. How to identify the global and local stability and extremality of these critical solutions is a challenge task. It turns out that many nonconvex problems in global optimization and computational science are considered to be NP-hard. In nonlinear dynamics, the so-called chaotic behavior is due to nonconvexity of the objective functions. In complex systems, even some qualitative questions such as solvability, regularity and stability are considered as the outstanding open problems.

In this talk, the speaker will first present some fundamental principles for modeling complex systems. Based on the definitions of objectivity and isotropy in continuum physics, a potentially powerful canonical duality theory is naturally developed. From the traditional oriental philosophy and some basic rules in systems theory, he will show a unified framework in complex systems and fundamental reasons that lead to challenging problems in different fields, including chaotic dynamics, phase transitions of solids, NP-hard problems in global optimization, and the paradox of Buridans donkey in decision sciences. By using the canonical duality theory, a unified solution form can be obtained for a large class of problems in nonconvex systems and global optimization, both global and local optimality conditions can be identified by a triality theory. For many nonconvex variational problems, the global optimal solutions are usually nonsmooth, and cannot be captured by any traditional Newton-type direct approaches. Applications will be illustrated by certain well-known challenging problems in analysis (such as phase transitions and control of chaotic systems) as well as NP-hard problems in global optimization and computational science (such as integer programming, network optimization, and TSP etc). Finally, some open problems and possible methodologies will be addressed.

The speaker hopes this talk will bring some new insights into complex systems and computational science

References: Gao, D.Y. (2000). Duality Principles in Nonconvex Systems: Theory, Methods and Applications. Kluwer Academic Publishers, Boston/Dordrecht/London, 2000, xviii+454pp. Gao, D.Y. (2009). Canonical duality theory: Unified understanding and generalized solution for global optimization problems, Computers & Chemical Engineering, 33:19641972. doi:10.1016/j.compchemeng.2009.06.009

Saffman-Taylor fingers in a wedge geometry

Mr Bennett Gardiner†
School of Mathematics
QUT
bennett.gardiner@qut.edu.au
5:00 pm Monday

The fingering instability that forms in a Hele-Shaw cell with rectangular geometry has been well studied (Saffman and Taylor, 1959). McClean and Saffman (1981) found that the regularising effect of surface tension explains the experimental result of the finger filling half the channel width for very low surface tension.

Vanden-Broeck (1983) used a clever trick to find that there is a countably infinite set of solutions, with surface tension selecting the most stable solution branch.

We attempt to solve the problem numerically, including the effects of kinetic undercooling (Dallaston, 2011). We note some inconsistencies with the asymptotic analysis of Chapman and King (2003). We also attempt to extend the methods of McClean and Saffman to a wedge geometry (Ben Amar, 1990).

Multiscale Methods for Geomagnetic Modeling

Christian Gerhards
UNSW
School of Mathematics and Statistics
gerhards.christian@gmail.com
12:00 pm Thursday

Recent satellite missions like CHAMP and Orsted have severely improved the understanding of the Earth's magnetic field, and the upcoming Swarm mission is continuing on this path. Fourier expansions in terms of spherical harmonics are the most popular tool to model the geomagnetic field. They are, however, not optimal if data is only locally available or if spatially localized features are to be reconstructed.

In this talk we present the application of multiscale methods to the modeling of the Earth's crustal magnetic field. Scaling kernels at low scales allow an initial approximation of the coarse global features while localizing wavelet kernels are used to refine the approximation. This way it is possible to emphasize spatially localizing features and to use unevenly distributed data sets. In particular, we want to indicate how the kernels can be optimized for the combination of globally available satellite data and only locally available data at the Earth's surface. On the one hand, the scaling kernels need to perform well for the downward continuation of the satellite data, and on the other hand, the corresponding wavelet kernels should reveal a good spatial localization at the Earth's surface.

Understanding first phase HIV decay dynamics through stage-dependent drug action

Dr James Gilmore, Anthony D. Kelleher, David A. Cooper, and John M. Murray
The University of New South Wales
james.gilmore@unsw.edu.au
12:20 pm Monday

Recent results have shown that the integrase inhibitor raltegravir produces a steeper phase IA decay of HIV RNA plasma virus levels than other antiretroviral drugs acting at different stages of viral replication (Murray et al. J Virol 2011). Further analysis has also shown that a slower decay (phase IB) occurs prior to the start of the usual second phase decay. To investigate these plasma virus decay dynamics we mathematically model the different stages of the HIV life cycle in CD4+ T cells: viral entry, reverse transcription, integration, and viral production. Our modeling shows that the differences in the phase IA slope across drug classes arise from a higher death rate of cells when they enter the productively infected stage. We find that productively infected cells have a half-life of approximately 8 hours, whereas cells in earlier stages of the infection cycle have half-lives similar to uninfected cells. This implies immune clearance is predominantly limited to the productively infected stage. Our model indicates the slowing from phase IA to IB results from new rounds of infection and the level at which this occurs is a better indicator of drug efficacy than the slope of the initial decay.

Local Sensitivity Analysis of Glucose Transporter Translocation in Response to Insulin

Catheryn Gray†, Adelle C. F. Coster
School Mathematics and Statistics
University of New South Wales
catheryn.gray@unsw.edu.au
5:20 pm Monday

When developing a mathematical model of a biological system there is an inherent tension between the desire to fully represent the underlying complexity of the biological system and the need to reduce the model to achieve computational tractability. On the one hand, we wish the model to provide insight into the physiology of the system, and hence the inclusion of a certain degree of biological complexity is essential. However, the inclusion of excessive biological detail can itself obscure the clarity we are aiming to achieve. Here we present a middle path between these two extremes.

We have investigated a model of insulin signaling and translocation of a glucose transporter (GLUT4) (Sedaghat, 2002). Steady state and stability analyses were performed on this system of 21 state variables. Furthermore, a simple method of local sensitivity analysis was established to investigate the behaviour of GLUT4 translocation in response to insulin. Mathematically and physiologically meaningful measures of the model output were investigated. These were used to identify critical nodes in the network and provide insight into the regulation of the system. Just as importantly, however, insensitive nodes were identified, leading to the development of a reduced parameter set.

In the future, this reduced parameter set will form the basis of a global sensitivity analysis of the system, and potentially contribute to structural improvements in the model in the light of new understanding of the interactions in the system.

Reference

Sedaghat, A. R., Sherman, A., and Quon, M. J. (2002) Am. J. Physiol. Endocrinol. Metab. 283, E1084-E1101

Heat conduction in a heterogeneous cooling fin – some interesting non-classical symmetry solutions

Dr Bronwyn Hajek, Raseelo J. Moitsheki
School of Information Technology and Mathematical Sciences
University of South Australia
Bronwyn.Hajek@unisa.edu.au
5:20 pm Monday

Cooling fins are widely used in many applications such as refrigeration, cooling computer processors and in air-cooled engines. Recently, more attention has been devoted to the construction of these fins using heterogeneous materials, so that the thermal conductivity of the fin is not constant throughout its length. The transient model (important for cooling fins in high-speed aircraft, solar systems and intermittently operating heat exchanges) is analysed using classical and non-classical symmetry techniques. Interesting analytical solutions can be constructed for some forms of the spatially dependent thermal conductivity.

A stochastic model for effect of hardware faults on supercomputers

Mr Brendan Harding†, Markus Hegland
Department of Mathematics
Australian National University
brendan.harding@anu.edu.au
1:00 pm Wednesday

As the biggest supercomputers continue to increase in size the probability of faults interrupting an application also increase. At exascale failures will be frequent enough that applications will need to be able to deal with these. We present simple models for the analysis of how faults in computing hardware can effect the numerical results of an application. To start with we will give a brief analysis of some basic collective operations like finding the global sum or maximum. Through this we will demonstrate some simple ways to reduce the impact of faults on these operations. This analysis is then developed into more complex operations like integration and the solution of PDE's using a generalisation of the combination technique. This analysis is an important tool as we work on developing a fault-tolerant framework for computing the solution to PDE's.

Shock-fronted travelling wave solutions arising in a model of tumour invasion

Kristen Harley†
Mathematical Sciences School
Queensland University of Technology
ke.harley@student.qut.edu.au
2:40 pm Wednesday

We investigate travelling wave solutions for a two-species model of malignant tumour invasion in one spatial dimension, where the mode of migration is purely haptotactic/advective. Both smooth and shock-fronted travelling waves have previously been identified for this model and these waves appear to be numerically stable.

A notable characteristic of shock-fronted waves is that they exhibit multiple time scales. By reposing the model as a singular perturbation problem we prove the existence of both smooth and shock-fronted travelling wave solutions using techniques from geometric singular perturbation and canard theory. In addition, this approach allows the extension of the proof to a more general model including a small amount of diffusion. A brief discussion of stability is also presented.

Bubble electrophoresis with four univalent ion species

Prof. John Harper
Mathematics Statistics and Operations Research
Victoria University of Wellington
john.harper@vuw.ac.nz
3:20 pm Monday

In 1996 Kelsall et al. reported electrophoretic experiments with oxygen bubbles in dilute solutions of several salts that were remarkably free of surfactants, but there is still no theory that can explain them completely, not even that of the present author in 2010. This paper investigates whether the trouble may have been due to ignoring all ions except those of the salt itself, by considering the simplest possible case beyond that: univalent ions of both salt and water, hence just four ionic species.

The theory assumes a double-layer thickness much smaller than the bubble radius, as it was in the experiments. It redevelops the theory on various hypotheses about the precise location of the free surface charge, and considers other possibilities for electrophoretic mobility varying with the applied electric field.

Reference: Harper,J.F. (2010) Electrophoresis of surfactant-free bubbles. J. Colloid Interface Sci. 350, 361-367

Modelling the Performance of Raingardens as Stormwater Treatment Devices

Dr Sharleen Harper
NIWA
Sharleen.Harper@niwa.co.nz
11:00 am Thursday

Raingardens (also known as bioretention devices) are landscaped features designed to improve the quality of stormwater runoff from nearby impervious surfaces. They generally consist of a porous soil layer planted with a suitable vegetation mix (e.g. grasses and shrubs) constructed in a shallow topographic basin. During a rainfall event, stormwater is conveyed to the surface of the raingarden where it percolates through the soil media to an underdrain. Contaminants in the stormwater, such as sediment and particulate or dissolved metals, are removed by filtration and/or adsorption as the stormwater percolates.

In studies to date, raingardens have demonstrated good to excellent performance in improving stormwater quality. There is limited basis for predicting the total contaminant removal during storm events, however, particularly in response to different local conditions. Recent monitoring of other filtration devices has shown that the performance of these devices in the field can be strongly influenced by local conditions, highlighting the need for a better understanding of the

treatment mechanisms across all types of stormwater filtration devices. In particular, the total capture is expected to be disproportionate across the range of particle sizes contained within sediments, as smaller particles are less efficiently removed. The objective of this research is to develop a mathematical model to simulate the performance of raingardens in removing sediments and particulate or dissolved metals from stormwater during a rainfall event. The model is intended to be as simple as possible, whilst remaining reasonably representative of the complex hydrology involved. This short talk will discuss the conceptual formulation of the model and a comparison against existing field data.

Modulation Theory for the Steady fKdVB Equation- Constructing Periodic Solutions

Laura Hattam†
Monash
Laura.Hattam@monash.edu
10:00 am Tuesday

The forced Korteweg-de Vries (fKdV) equation describes near resonance, weakly non-linear and weakly dispersive long waves propagating in various mediums with external forcing. With the addition of a linear damping term, it becomes the fKdV-Burgers (fKdVB) equation. We present a multiple-scale perturbation technique for obtaining asymptotic solutions to the fKdVB equation. The first order solution in the perturbation hierarchy is the modulated cnoidal wave equation. From the second order equation in the hierarchy, we find a system of odes governing the modulation of the properties of the cnoidal wave. Using this, we then construct periodic solutions, and examine the stability of these solutions.

Snakes and Ladders Heuristic for the Hamiltonian Cycle Problem

Dr Michael Haythorpe, Pouya Baniasadi, Vladimir Ejov, Jerzy Filar, Serguei Rossomakhine
School of Computer Science, Engineering and Mathematics
Flinders University
michael.haythorpe@flinders.edu.au
12:40 pm Thursday

The Hamiltonian cycle problem (HCP) is a graph theory decision problem that can be stated simply: given a graph containing N vertices, determine whether any simple cycles of length N exist in the graph, or not. HCP has become famous both because it is NP-complete, and because of its close relation to the Traveling Salesman problem. We present a new, polynomial complexity, heuristic for solving HCP, called the Snakes and Ladders Heuristic (SLH). Although not guaranteed to find a Hamiltonian cycle, we have observed that SLH is successful even in cases where such cycles are extremely rare. There are two basic transformations that power SLH, and we prove that these are sufficient to allow any Hamiltonian cycle to be found in any graph, regardless of the initial vertex labelling. The use of a suitable stopping criterion ensures the heuristic terminates in polynomial time. This presentation includes a comparison of the performance of SLH to that of the best modern algorithms for solving HCP.

On the numerical solution of the Vlasov-Maxwell equations

Prof. Markus Hegland
MSI
ANU
markus.hegland@anu.edu.au
4:40 pm Monday

Kinetic equations, and in particular the Vlasov equations have been successfully applied to model plasmas occurring in future fusion reactors. The numerical solution of these equations is challenging in numerous ways. One problem is the curse of dimension as these equations are formulated in the six-dimensional state space. Even a reduction to five dimensions in the gyrokinetic equations has the same problem and the size of grids usable is severely limited.

I will talk about the application of the sparse grid combination technique which allows the usage of existing code and small grids. The equations are numerically solved for several such grids and combined to get more accurate solutions. The

discussion will focus on the GENE code and its application to fusion plasmas.

A second-order accurate finite volume method for solving the two-sided space fractional diffusion equation

Mrs Hala Hejazi†, H. Hejazi, T. Moroney, F. Liu
hala.hejazi@student.qut.edu.au
10:40 am Tuesday

Transport processes within heterogeneous media may exhibit non-classical diffusion or dispersion; that is, not adequately described by the classical theory of Brownian motion and Ficks law. We consider a two-sided space fractional diffusion equation based on a fractional Ficks law. The equation involves the Riemann-Liouville fractional derivative which arises from assuming that particles may make large jumps.

In this work, we present a second-order accurate finite volume method for solving the two-sided space fractional diffusion equation on a one-dimensional domain. The finite volume approach deals naturally with the equation in conservative form. The novel spatial discretisation employs second-order fractionally-shifted Grnwald formulas to discretise the Riemann-Liouville fractional derivatives at control volume faces in terms of function values at the nodes. Results of numerical experiments are presented to demonstrate the effectiveness of the approach.

How population heterogeneity influences epidemic dynamics

Dr Roslyn Hickson, Mick Roberts
School of Mathematical and Physical Sciences
University of Newcastle
Roslyn.Hickson@newcastle.edu.au
12:40 pm Thursday

An important concern in public health is what population group should be prioritised for vaccination. To this end, we present a model capable of using arbitrary distributions for population susceptibility, and corresponding infectivity distributions. We consider three scenarios: first, a population with heterogeneous susceptibility with a uniform distribution, but homogeneous infectivity. Second, a uniform heterogeneously susceptible population with linear heterogeneous infectivity functions, where the most susceptible are either the most or least infectious. Finally, we consider the effects of pre-epidemic immunity, ostensibly through vaccination, on the epidemic dynamics.

Acid-mediated tumour growth

Mr Andrew Holder†, Marianito Rodrigo
School of Mathematics and Applied Statistics
University of Wollongong
abh920@uowmail.edu.au
10:00 am Monday

Mathematical modelling of tumour growth has been under-utilised in the understanding of tumours and resulting treatment strategies. I believe mathematics has an important role to play in tackling this significant health issue. Mathematics is able to predict and discover information about tumour growth and the effect certain treatments have on this growth long before human trials are started. This not only is a cheaper alternative but it pinpoints which treatments may be the most successful and reduces the amount of trial and error that would be required if only experimental methods were available.

A brief introduction to the properties of avascular tumours and acid-mediated tumour growth will be given. I will then present the work I have conducted so far for modelling the invasive process of acid-meditated tumour growth based on the work of Gatenby and Gawlinski.

Faraday waves in radial outflow

Mr David Horsley†, Larry Forbes
School of Mathematics and Physics
University of Tasmania
david.horsley@utas.edu.au
10:40 am Monday

Faraday waves are parametrically excited standing waves. The classical example of these waves occurs when a fluid is placed atop a vertically oscillating base. When the oscillation are of twice the natural frequency of a particular mode, resonant surface waves of that mode appear.

In this talk, we shall discuss an extension of this phenomenon to radial outflow. This analogue consists of a gravitationally attracting line source of fluid, embedded in a background fluid of lesser density. When the strength of this source oscillates, resonant waves can appear on the interface between the two media.

We shall explore this phenomenon through an ideal fluid model, of which both linearised and nonlinear numerical solutions have been found. In addition a viscous Boussinesq model will be presented.

Living on the edge of chaos: Painlev equations through geometry

Mr Philip Howes†, Prof. Nalini Joshi
Mathematics
University of Sydney
howespt@gmail.com
3:20 pm Monday

Painlevé equations arise as natural extensions to equations governing elliptic functions. It comes as no surprise then that the solutions are generically highly transcendental and appear in non-linear physical situations. By studying both continuous and discrete from the point of view of singularities (in particular algebraic geometric interpretations), we can determine many interesting results, and attempt to unify seemingly different ideas under the one umbrella. Note: If time permits, there may me ”music”.

Drug-likeness: statistical tools, chemico-biology space, cartesian planes, drug databases: a case study

Prof. Irene Hudson, Shanjeea Shafi, Sean A Hudson, Andrew D Abell
School of Mathematical and Physical Sciences
The University of Newcastle
irenelena.hudson@gmail.com
1:00 pm Wednesday

Optimization of a large number (N) of variables in two different domains, the chemical and biological, is fundamental to successful drug discovery. Relevant variables concern both physico-chemical properties of the ligand, such as molecular weight (MW), to more complex measures related to its bioavailability and toxicity and its affinity towards the target. Whilst navigating through such an N-dimensional space using the ligands actual but often not available potency toward the target (i.e. IC50 or related metrics) might yield good inhibitors it does not automatically result in effective drugs in the clinical setting. In drug discovery the challenge is to identify regions of chemical space that contain biologically active compounds for given biological targets (i.e. proteases, kinases etc). Lipinski and Hopkins (2004) suggested that within the continuum of chemical space, there should be discrete regions occupied by compounds with specific affinities towards particular biological targets. The question of which variables (or coordinate systems) would facilitate such segregation, however, was not delineated in their seminal paper and is as yet not determined. This review looks at the possibility of identifying regions of chemical and biological space with a higher probability of yielding clinical target-specific drugs. Can a mixture of conceptual, numerical and visual cartesian representations of targetligand (drug) databases of inhibitors and commercial drugs lead to a more effective drug discovery process? What is the true definition of druglikeness? How best to employ it to reduce attrition rate in drug discovery? Can we estimate oral versus non-oral druglikeness? Can we distinguish drugs from non-drugs? We discuss a druglike filter and recent advances in the prediction of oral druglikeness. What role is there for statisticians in obtaining so-called structural fingerprints? Some areas discussed are SOMs, mixture and Bayesian methods, SVMs, pattern recognition, feature selection, NNs. Reference Lipinski, C. & Hopkins, A. (2004) Navigating chemical space for biology and medicine. Nature 432, 855861.

Transition Analysis of a Single Species Logistic Model Exhibiting an Allee Effect in a Slow Variation

Mrs Majda Idlango†, M. A. Idlango, J. J. Shepherd, J. A. Gear
School of Mathematical and Geospatial Sciences
RMIT University
Majda.Idlango@rmit.edu.au
10:00 am Wednesday

In general, the Allee effect in a single species population model can be simply described as the phenomenon where the population grows faster when the species are at high population density than it would if the population were at low population density. That is, the Allee effect reduces the population growth at low densities.

The dynamics of such models can be influenced by regular environmental changes such as food availability etc and so parameters of population models may vary with time on one or different scales. In earlier work we have applied a multi-timing technique to construct general approximate expressions for the evolving population in the cases where the population survives to a (slowly varying) finite positive limiting state; and that where the population declines to extinction. This talk extends these results to provide an approximate solution to evolving population through the transition where the roles of the parameters interchange . The results agrees well with numerical calculations for particular instances of the changing model parameters

Dynamos in Spheroidal and Ellipsoidal Geometries

Dr David Ivers
Mathematics and Statistics
University of Sydney
david.ivers@sydney.edu.au
12:20 pm Tuesday

The kinematic dynamo is solved for in an electrically-conducting fluid of uniform magnetic diffusivity occupying spheroidal or (tri-axial) ellipsoidal volumes with insulating exterior. The method uses a class of spheroidal or ellipsoidal toroidal-poloidal fields in a non-orthogonal coordinate system. A homogeneous non-isotropic scaling of coordinates and fields leads to a modified form of the magnetic induction equation with geometric anisotropic diffusion. The alpha-effect, even if isotropic, is transformed into anisotropic form. Angle is discretised using a spherical harmonic Galerkin method. Radial dependence is discretised using finite-differences on a grid centred at interior grid point and one-sided at the insulating boundary. Other forms of radial discretisation such as Chebychev collocation are possible. The current-free condition must be solved explicitly in the insulating exterior. Dynamo solutions are presented for several flows and alpha-effects in different ellipsoids.

Modelling Tissue Inflammatory Response: Chemotaxis-Reaction-Diffusion Equations (CRDEs)

Mr Aidin Jalilzadeh†
Department of Mathematics and Statistics
University of Otago
aidin@maths.otago.ac.nz
12:20 pm Wednesday

The inflammatory response of tissue to injury or invasion is a complex phenomenon involving vascular, humoural and cellular factors. In this work we have developed a spatio-temporal mathematical model consisting of a system of diffusion-advection-reaction equations, to capture some aspects of tissue inflammatory response. The proposed model accounts for (1) antigen recognition, (2) the effectors function (activation/regulation/inhibition), (3) elimination of antigen and resolution of the infection and (4) returning the immune cells back to a steady state.

Chemotaxis is the major cytotaxic effect that leads the movement of leukocytes to the site of infection. We have formulated this phenomenon via gradient-based models, where chemical concentration gradient creates directional bias resulting in the so called chemotaxis.

Matlab's FEM suite is used for solving the system and running simulations. We have been able to simulate real scenarios such as the resolution of acute infection as well as recurring/chronic events.

MIP models for optimisation of locations for prescribed burning

John, James P Minas
Mathematical and Geospatial Sciences
RMIT University
john.hearne@rmit.edu.au
10:40 am Thursday

Prescribed burning is one option available to fire and land management agencies to reduce fuel loads and hence reduce the risk of wildfires. Planning for this activity is a complex undertaking with decisions required on the spatial location, the extent, and timing of controlled burns. We formulate some MIP problems to deal with these issues at the landscape-level in the presence of resource limitations. We generate a number of fuel treatment patterns and landscape metrics identified in the fire behaviour literature with a view to modifying the behaviour and effects of large wildfires. Methods for incorporation of a range of ecological, operational and cost constraints are also considered.

Optimising Reclaimer Schedules

Ms Reena Kapoor†, Martin Savelsbergh
School of Mathematical and Physical Sciences
University Of Newcastle, Australia
reena.kapoor@uon.edu.au
10:40 am Monday

A reclaimer is a large machine used in bulk material handling, for example in the stockyard of a coal terminal. Effective management of the stockyard at a coal terminal is necessary to ensure high throughput. A crucial component is the scheduling of the reclaimers. We consider an abstract model of reclaimer scheduling and study different variants to gain insights into effective scheduling policies. We consider a variant in which the positions of the stockpiles in the stockyard are given and the optimal reclaimer schedule needs to be determined as well as a variant in which the positions of the stockpiles and the schedule of the reclaimers has to be determined simultaneously. We also consider variants in which the reclaim order of the stockpiles is pre-specified. We seek to determine the computational complexity of each variant and to develop algorithms for their solution. The results of computational experiments for some of the variants will be presented.

Scheduling unit processing time arc shutdown jobs to maximize network flow over time

Ms Simranjit Kaur†, Natashia Boland, Thomas Kalinowski, Reena Kapoor
School of Mathematical and Physical Sciences
University of Newcastle, Australia
simranjit.kaur@uon.edu.au
10:40 am Wednesday

Many real world complex problems can be viewed as networks with arc capacities, for example, rail networks, or supply chains, in which system throughput needs to be maximized. Arcs in such a network represent important components of

the corresponding system, the condition of which may degrade over time. Maintenance of these components (arcs of the network) is important to maintain their productivity. But every maintenance activity incurs some loss of productivity as the arc will be unavailable during its maintenance. In this talk we discuss optimization models for scheduling arc maintenance so as to maximize the throughput of the network, and focus on the case in which each maintenance task requires a single period. We identify a number of characteristics that are relevant for the complexity of the problem. We also present an algorithm for single transhipment node networks that performs better than the state-of-the-art method on some problem classes.

On weak approximation of stochastic differential equations through hard bounds by mathematical programming

Dr Reiichiro Kawai
School of Mathematics and Statistics
University of Sydney
reiichiro.kawai@maths.usyd.edu.au
10:00 am Wednesday

Upper and lower hard bounds of the expected value on stochastic differential equations can be obtained with the help of the mathematical programming and the Dynkin formula, without recourse to Monte Carlo sample paths simulation. In this paper, we show that feasible solutions of those optimization approaches further provide useful additional information. Namely, feasible solutions provide upper and lower bounds for arbitrary intermediate times and/or different initial states. We also show that the optimization approach can also be applied to stochastic differential equations with a random initial state. Some numerical results are provided to illustrate the effectiveness of the proposed method.

Constructing Interpolating Curves via Optimal Control

Dr Yalcin Kaya, Lyle Noakes
School of Mathematics and Statistics
University of South Australia
yalcin.kaya@unisa.edu.au
4:00 pm Monday

We study the problem of finding an interpolating curve passing through prescribed points in the Euclidean space. The interpolating curve minimizes the pointwise maximum length of its acceleration. We re-formulate the problem as an optimal control problem and employ simple but effective tools of optimal control theory. We characterize solutions associated with singular and nonsingular controls. We reduce the infinite dimensional interpolation problem to an ensuing finite dimensional one and derive closed form expressions for interpolating curves. Consequently we devise numerical techniques for finding interpolating curves and illustrate these techniques on examples.

Parallel Solution of Regression Problems Using Sparse Grids and Alternating Direction Method of Multipliers

Valeriy Khakhutskyy†, Markus Hegland, Dirk Pflger
Technische Universitt Mnchen, Germany
khakhutv@in.tum.de
3:40 pm Wednesday

We consider the application of sparse grids for solving regression problems in data mining. Regression has a lot of applications in data mining in a large variety of different areas, e.g. prediction of real estate prices, healthcare risks, or photometric redshift of galaxies. Compared to established machine learning techniques, like artificial neural networks or support vector machines, sparse grids produce an approximant that is easier to analyze and to interpret [1]. High-dimensional regression problems present a challenge for sparse grids and are usually tackled by either dimensionality reduction (e.g. using PCA), or by approximation of the high-dimensional solution by a combination of sub-solutions in lower dimensional space (e.g. using ANOVA decomposition [2]), or by parallelizing the solution algorithms [3, 4].

In this work we focus on the last kind of techniques and investigate the solution of regression problems with sparse grids using alternating direction method of multipliers (ADMM) [5]. We present some computational experiments which use ADMM for hierarchical basis sparse grids approximation and in particular discuss the convergence rates.

References: [1] J. Garcke, M. Griebel, and M. Thess, Data mining with sparse grids, Computing, vol. 67, no. 3, pp. 225253, 2001. [2] M. Hegland, Adaptive sparse grids, ANZIAM Journal, vol. 44, no. April, p. C335C353, 2003. [3] J. Garcke, M. Hegland, and O. Nielsen, Parallelisation of sparse grids for large scale data analysis, Forschung, pp. 699699, 2003. [4] A. Heinecke and D. Pflger, Multi- and Many-Core Data Mining with Adaptive Sparse Grids, 8th ICCF, pp. 29:129:10. ACM, New York, USA, May 2011. [5] S. Boyd, N. Parikh, E. Chu, B. Peleato, and J. Eckstein, Distributed Optimization and Statistical Learning via the Alternating Direction Method of Multipliers, Foundations and Trends in Machine Learning, vol. 3, no. 1, pp. 1-122, 2010.

Using models to uncover dynamical features of malaria infections that are difficult to measure

Mr David Khoury†, Deborah Cromer, Kylie James, Shannon E. Best, Ashraful Haque, Miles P. Davenport
Centre for Vascular Research
University of New South Wales
david.khoury@student.unsw.edu.au
1:00 pm Monday

Many malaria-infected red blood cells stick to blood vessels during malaria infection, and so escape passage through the spleen (and other organs), where they might otherwise be destroyed. Neither the dynamics of sequestration nor of parasite destruction are well understood, due to the difficulty of measuring non-circulating blood parasites. Both are believed to be age-dependent, targeting the more mature parasites in the population.

We formulate an age-structured partial differential equation (PDE) model of parasite dynamics and sequestration to examine the mechanisms of parasite destruction and sequestration. Our analysis of this model reveals an almost paradoxical property of the parasite population; that a high proportion of old parasites in the blood will result from a high level of destruction of the very oldest parasites. This is a useful property to identify given our observations in malaria-infected mice of very high proportions of old parasites. The results of this modelling combined with experimental data lead us to the hypothesis that the mechanism of parasite destruction does not have merely a marginal preference for old parasites, but is highly specific in targeting old parasites. Therefore, sequestration will provide an advantage to parasite growth as long as it begins at an age prior to the age at which a parasite becomes strongly targeted for destruction. Such behaviour is consistent with observations that sequestration begins at a very specific life-stage of the parasite during infection.

An optimized combination technique for the gyrokinetic eigenvalue problem

Christoph Kowitz†, Markus Hegland
Institut fr Informatik
Technische Universitt Mnchen
kowitz@in.tum.de
10:20 am Wednesday

The simulation of hot fusion plasmas via the five-dimensional gyrokinetic equations is computationally intensive with one reason being the curse of dimensionality. Using the sparse grid combination technique could reduce the computational effort. Finding the positive real eigenvalues of the gyrokinetic eigenvalue problem is one aspect of linear gyrokinetics. An opticom algorithm is presented, which is reformulating the original opticom minimization principle to suit the eigenvalue computation used in the gyrokinetic code GENE. The algorithm is applied onto an analytic test problem to show its feasibility.

The best proximity point theorems for generalized proximal contraction mappings

Dr Poom Kumam, Poom Kumam
Mathematics
King Mongkut's University of Technology Thonburi (KMUTT)
poom.kum@kmutt.ac.th
11:00 am Thursday

The purpose of this paper is to establish the best proximity point theorems for generalized contractions mappings, there by producing optimal approximate solutions of certain fixed point equations. In addition to exploring the existence of the best proximity point for generalized contractions, an iterative algorithm is also presented to determine such an optimal approximate solution.

The Linear Regression and Fuzzy Linear Regression based Medical Service Value Models for Informal Workers in Thailand

Wiyada Kumam†, Wiyada Kumam, Adisak Pongpullponsak
Department of Mathematics
King Mongkut's University of Technology Thonburi (KMUTT)
wiyada.kum@mail.rmutt.ac.th
12:40 pm Wednesday

The purpose of this research is to develop an estimation model for non-surgical medical service value of informal workers for the social security system in Thailand. Two methodologies, linear regression and fuzzy linear regression have been chosen to develop the model, and then the estimates obtained from each model are compared to the actual costs from hospitals. The results demonstrated that the medical service value model established from fuzzy linear regression method gave the closest estimates to the real expenses.

Multi-level quasi-Monte Carlo finite element methods for a class of elliptic partial differential equations with random coefficients

Dr Frances Kuo, Christoph Schwab, Ian H. Sloan
University of New South Wales
School of Mathematics and Statistics
f.kuo@unsw.edu.au
12:20 pm Thursday

Quasi-Monte Carlo (QMC) methods are applied to multi-level Finite Element (FE) discretizations of elliptic partial differential equations (PDEs) with a random coefficient, to estimate expected values of linear functionals of the solution. The expected value is considered as an infinite-dimensional integral in the parameter space corresponding to the randomness induced by the random coefficient. We use a multi-level algorithm, with the number of QMC points depending on the discretization level, and with a level-dependent dimension truncation strategy. In some scenarios, we show that the overall error is $\mathcal{O}(h^2)$, where h is the finest FE mesh width, or $\mathcal{O}(N^{-1+\delta})$ for arbitrary $\delta > 0$, where N is the maximal number of QMC sampling points. For these scenarios, the total work is essentially of the order of one single PDE solve at the finest FE discretization level. The analysis exploits regularity of the parametric solution with respect to both the physical variables (the variables in the physical domain) and the parametric variables (the parameters corresponding to randomness). Families of QMC rules with "POD weights" ("product and order dependent weights") which quantify the relative importance of subsets of the variables are found to be natural for proving convergence rates of QMC errors that are independent of the number of parametric variables. Conditions on the data of the problem to achieve a certain rate of convergence coincide with the sufficient conditions obtained in Cohen, De Vore, and Schwab (2010).

Buckling of a cantilever plate uniformly loaded in its plane with applications to surface stress and thermal loads

Mr Michael Lachut†, Prof. John E. Sader (Supervisor)
Mathematics and Statistics
University of Melbourne
M.Lachut@ms.unimelb.edu.au
3:40 pm Monday

Buckling of elastic structures can occur for loads well within the proportionality limit of their constituent materials. Given the ubiquity of beams and plates in engineering design and application, their buckling behavior has been widely studied. However, buckling of a cantilever plate is yet to be investigated, despite the widespread use of cantilevers in modern technological developments. Here, we address this issue and theoretically study the buckling behavior of a cantilever plate that is uniformly loaded in its plane. Applications of this fundamental problem include loading due to uniform temperature and surface stress changes. This is achieved using a scaling analysis and full three-dimensional numerical solution, leading to explicit formulas for the buckling loads. Unusually, we observe buckling for both tensile and compressive loads, the physical mechanisms for which are explored.

We also examine the practical implications of these findings to modern developments in ultra sensitive micro- and nano-cantilever sensors, such as those composed of silicon nitride and graphene.

A Modified DSMC Method for Simulating Unsteady Flows

Mr Daniel Ladiges†, John Sader
Department of Mathematics and Statistics
University of Melbourne
dladiges@ms.unimelb.edu.au
10:40 am Tuesday

The study of micro and nano scale gas flows has a wide range of applications, particularly with respect to micro-electromechanical systems (MEMS). The length scales of these systems are often of similar order to the mean free path of the gas in which they operate, resulting in a Knudsen number larger than zero. In this regime, rarefaction of the gas must be considered when performing simulations.

A popular method for simulating rarefied gas flows is direct simulation Monte Carlo (DSMC). The original DSMC method is effective for simulating medium to large Mach number flows, and recent modifications to this method have made it suitable for low Mach number flows commonly associated with micro/nano systems. In this talk we present a further refinement to the DSMC method for the simulation of unsteady low Mach number flows. Our approach enables the simulation of oscillatory flows while preserving the efficiency of a steady flow simulation.

Managing heterogeneity in the study of neural oscillator dynamics

Carlo Laing, Ben Smith,Yu Zou,Yannis G. Kevrekidis
Massey University
c.r.laing@massey.ac.nz
11:40 am Thursday

We consider a coupled, heterogeneous population of relaxation oscillators used to model rhythmic oscillations in the pre-Botzinger complex. By choosing specific values of the parameter used to describe the heterogeneity, sampled from the probability distribution of the values of that parameter, we show how the effects of heterogeneity can be studied in a computationally efficient manner. When more than one parameter is heterogeneous, full or sparse tensor product grids are used to select appropriate parameter values. The method allows us to effectively reduce the dimensionality of the model, and it provides a means for systematically investigating the effects of heterogeneity in coupled systems, linking ideas from uncertainty quantification to those for the study of network dynamics.

A mixed finite element method for the biharmonic problem using biorthogonal or quasi-biorthogonal systems

Dr Bishnu Lamichhane
MAPS
University of Newcastle
bishnu.lamichhane@newcastle.edu.au
12:00 pm Thursday

We consider some mixed finite element methods based on biorthogonal or quasi-biorthogonal systems for the biharmonic problem. Using different finite element spaces for the stream function and vorticity, this approach leads to a formulation only based on the stream function. We prove optimal a priori estimates for both stream function and vorticity.

Multiscale methods for the Stokes problem on bounded domains

Quoc Thong Le Gia, Andrew Chernih
Mathematics and Statistics
University of New South Wales
qlegia@unsw.edu.au
5:00 pm Monday

We investigate the application of radial basis functions for the approximation with collocation of the Stokes problem on a bounded domain. The approximate solution is constructed in a multi-level fashion, each level using compactly supported radial basis functions with decreasing scaling factors. We give sufficient conditions for convergence and stability analysis of the symmetric collocation method. Numerical experiments support the theoretical results.

Envelope Solitons in Barotropic and Baroclinic Flows

Mr David Lee†
david.lee@monash.edu
Monash University
david.lee@monash.edu
12:40 pm Tuesday

While not as widely discussed as long wave soliton models of atmospheric and oceanic phenomena, envelope soliton solutions to the nonlinear Schrödinger equation have been proposed to describe events such as mid latitude planetary scale dipole blocks, Rossby wave breaking in the extratropical tropopause and equatorial Rossby-gravity ocean waves. Despite these applications, most studies have been limited to the case of constant zonal shear, and little work has been done on the effects of baroclinicity or variable shear on these weakly nonlinear structures. This talk will discuss the effects of variable shear, stratification and topographic forcing on small amplitude oceanic envelope solitons at mid latitudes, as derived analytically from perturbation analysis, and observed numerically in a semi-Lagrangian, spectral element model of the layered quasi-geostrophic equations. While meridionally varying shear is found to primarily modify the range of unstable wave numbers and their growth rates subject to edge wave instabilities, the coupling of a thin upper layer to a deep lower layer is found to modify the group velocity of the upper layer disturbance.

Statistical Inference and Medical Image Segmentation

Dr Gobert Lee, Gobert Lee, Mariusz Bajger
School of Computer Science, Engineering and Mathematics
Flinders University
gobert.lee@flinders.edu.au
4:40 pm Wednesday

(Submission to be considered for Stat sessions, thanks)

Image segmentation can be roughly presented as the grouping of individual image pixels into (meaningful/useful) partition of regions or objects. It is an important area common to a number of research fields such as image processing, computer vision and machine learning. Although a number of algorithms and approaches have been proposed, automated image segmentation continues to be a tantalizing and challenging problem. In this paper, we look at image segmentation as an inference problem and describe the Statistical Region Merging technique (Nock et al; 2004). We will further apply the technique in the segmentation of CT images.

What to do when scheduling is not followed - the issue of unbalanced longitudinal data

Mrs Lucy Leigh†, Lucy Leigh, Professor Irene L Hudson
Faculty of Science and IT
University of Newcastle
Lucy.Leigh@newcastle.edu.au
10:40 am Tuesday

Unbalanced data is common in longitudinal studies, where responses are often missing due to drop-out, death, loss to follow up or missed appointments. This leads to unbalanced data i.e. a different number of responses at each time point. Also leading to unbalanced data is the case of subject-specific response times. Participants may be late or early for scheduled appointments, or come in for off-schedule visits. As a result, each participant has a unique set of response times. Unbalanced data affects the range of modelling possibilities available for the longitudinal analysis. Also affecting the choice of model is whether or not the missingness is ignorable (MCAR or MAR) or non-ignorable (NMAR). If the missing is MCAR or MAR, analysis can usually proceed without causing bias to the parameter estimates. If missing is NMAR then bias may be introduced to estimates, and other modelling methods may be required. This review looks at various methods presented in the literature for dealing with unbalanced data in longitudinal analyses. Such methods include GEEs, mixed models, joint models and pattern mixture models.

(for submission to the statistics presentation sessions)

Alignment-free comparison of biological sequences

Dr Paul Leopardi, Conrad Burden, Sylvain Foret
Centre for Bioinformation Science
The Australian National University
paul.leopardi@anu.edu.au
5:20 pm Monday

The D2 statistic, which counts the number of exact word matches between two sequences, and its variants can potentially be used as a tool to characterize the similarity and differences between biological sequences. This talk describes work in progress towards using D2 as a tool to detect structure within the non-coding part of the genome.

Pathways of Carcinogenesis: Tumour Progression and Treatments

Mr Erwin Lobo†, Dr. Guy Lyons, Dr. Mary Myerscough
Mathematics and Statistics
The University of Sydney
erwin@maths.usyd.edu.au
3:20 pm Monday

Carcinogenesis is traditionally thought to progress through a series of ever increasingly malignant clones, in linear pathway known as lineal evolution. We consider a set of alternative pathways, where progression to malignancy is achieved because of cooperation between pre-malignant clones, known as interclonal cooperativity, through mathematical modelling.

Our model is a free-lattice hybrid model that consists of two components to represent cells and the tissue medium. We

study the implications of tumour progression via interclonal cooperativity using the model, and focus on the clinical impact of different types of surgical and cytotoxic treatments in each of the pathways.

Linear vector optimization – algorithms and applications

Andreas Loehne
Institute for Mathematics
MLU Halle-Wittenberg
andreas.loehne@mathematik.uni-halle.de
3:40 pm Monday

Linear vector optimization, algorithms and applications

Benson's outer approximation algorithm is a fundamental tool for solving linear and convex vector and set optimization problems. We provide several improvements of the primal and dual algorithm for linear problems. The main advantage of the new variant is that only one linear program has to be solved in each iteration (rather than two or three). Problems with arbitrary pointed solid polyhedral ordering cone can be solved, which is important for certain application in Mathematical Finance. Moreover, the new algorithms cover the case of unbounded problems. We point out the role of Benson's algorithm in algorithms to solve set optimization problems. Numerical examples are discussed.

Solving the integrated airline recovery problem using column-and-row generation

Mr Stephen Maher†
School of Mathematics and Statistics
University of New South Wales
stephen.maher@unsw.edu.au
10:20 am Monday

The airline recovery problem is a very large and complex problem, generally solved as a series of sequential stages by the airline operations control centre. There is an expectation that the integration of two or more of these recovery stages will improve the computational performance of this process. This talk will present an approach integrating the schedule, crew and aircraft recovery stages. To achieve acceptable solution runtimes, this problem is solved by column-and-row generation. As a key component to this technique, the implementation of row generation in a column generation framework will be discussed. The results demonstrate the benefits of column-and-row generation over a standard column generation approach in both solution quality and runtime.

The Morse and Maslov Indices for Periodic Problems

Dr Robert Marangell, C.K.R.T. Jones, Y. Latushkin
School of Mathematics and Statistics
University of Sydney
robert.marangell@sydney.edu.au
10:40 am Thursday

This talk will focus on Hill's equations with matrix valued periodic potentials. For such equations, we will show the relationship between the Morse index - the number of unstable eigenvalues, and a Maslov index - the number of signed intersections of a path in the space of Lagrangian planes with the so-called train of a fixed plane.

Numerical solutions for thin film flow down the outside and inside of a vertical cylinder

Lisa Mayo†, Scott McCue, Timothy Moroney
Mathematics
Queensland University of Technology
lisa.mayo@student.qut.edu.au
12:20 pm Monday

A numerical study is presented to examine the fingering instability of a gravity-driven thin liquid film flowing down a vertical cylinder. The lubrication model which governs the evolution of the flow is dependent on two parameters; the first measures the dimensionless cylinder radius and determines the contribution of substrate curvature to the fingering formations, and the second allows the user to switch between the three regimes of flow on the inner and outer cylinder walls, and flow down a vertical plane. Fully three–dimensional simulations with initial conditions given by small perturbations of the axisymmetric travelling wave solutions depict a fingering pattern at the contact line of the film for all three cases. When compared to flow down a vertical plane, we find that curvature on the outer wall of a cylinder tends to increase the instability of the flow, while that on the inner wall has a stabilising effect.

Intriguing nonlinearity in a SIRS model of disease transmission with immune boosting

Dr James McCaw, Federico Frascoli, Mathew Dafilis
Melbourne School of Population Health
University of Melbourne
jamesm@unimelb.edu.au
10:40 am Tuesday

A susceptible-infectious-recovered-susceptible (SIRS) model of human-to-human disease transmission with immune boosting (the SIRWS model), initially developed to understand the fluctuations in the prevalence of pertussis, is shown to be capable of supporting widespread unforced oscillatory dynamics. We will show that this oscillatory behaviour is explicitly sensitive to the assumed value of the lifespan parameter of the model, with variations in the lifespan changing the ability of the model to support sustained unforced oscillations.

Many dynamical model formulations in infectious disease epidemiology are more faithfully studied when the fundamental model architecture is subjected to periodic perturbation commensurate with annual variations in transmissibility. Such formulations are known as “seasonally-forced” models and in the typical scenario the transmission parameter is (co)sinusoidally modulated on an annual basis by some small factor.

Our investigations of a typically seasonally-forced variant of the SIRWS model indicate that it is capable of supporting a wide variety of nonlinear behaviours within biologically and epidemiologically supported parameter ranges. Forced oscillatory dynamics of low-integer periods, ranging from dynamics with an annual period, jumping to period 2, up to period 9 have been discovered to date in our studies. These behaviours include cases where the low-order behaviour predominates, nearby in parameter space to scenarios with subharmonics present, giving rise to an overall long-period oscillation. Early evidence suggests the model is also capable of supporting exotic nonlinear behaviour including quasiperiodicity and chaos. Our findings provide us with an opportunity to reflect on the impact of variations in transmissibility and seasonality on disease behaviour, consistent with our observed modelled behaviours.

Multiscale modelling of sausage-shaped cell migration leads to a continuum description with degenerate diffusion

A/Prof. Scott McCue, Matthew Simpson, Ruth Baker
School of Mathematical Sciences
Queensland University of Technology
scott.mccue@qut.edu.au
4:40 pm Wednesday

Studying cell invasion, even in simple scratch assays, is important for understanding the underlying processes in wound healing and tumour growth, for example. Continuum models of cell invasion typically involve reaction-diffusion PDEs with linear diffusion, where the diffusive component of cell migration arises from random cell motility. A consequence is that mathematical solutions involve information propagating infinitely fast, which strictly speaking is not biological perspective. An alternative approach is to use models with nonlinear degenerate diffusion, which has the advantage of allowing solutions with compact support and well-defined fronts of cell populations advancing with a finite velocity towards a region of zero population. An important issue, which has for the most part been left unresolved, is to quantify which fundamental features at the cell level determine whether the diffusion is linear, degenerate nonlinear, or neither. In this study, we use a multiscale approach based on a latticed-based exclusion process to provide a link between individual-based and continuum models and show that the migration of elongated rod-shaped cells is connected to the well-known porous media equation, with the exponent in the nonlinear diffusion term related to the aspect ratio of the cell; for round cells with aspect ratio of one, this model reduces to linear diffusion, as expected. Our work provides a physical motivation for using nonlinear degenerate diffusion to represent cell motility in continuum models.

This is joint work with Dr Mat Simpson from QUT and Dr Ruth Baker from Oxford.

Mitochondrial Calcium Handling and the Interstitial Cells of Cajal

Dr Shawn Means, Leo Cheng
Auckland Bioengineering
University of Auckland
s.means@auckland.ac.nz
5:00 pm Wednesday

The Interstitial Cells of Cajal (ICC) generate pacemaking signals controlling contractions of surrounding smooth muscle tissue in the gastrointestinal tract. The mechanism by which they generate these signals is not well known, although calcium (Ca2+) transport between the endoplasmic reticulum (ER) and mitochondria (MT) is shown to be crucial. Precisely how their interaction influences pacemaking signaling is not clear, yet a better understanding of the MT modulation of cytosolic Ca2+ may provide insights into the pacemaking mechanism. We thus aim to extend our previous ICC Ca2+ modeling efforts to include recent experimental data and updated models of MT Ca2+ transporters to facilitate exploration of the ER-MT Ca2+ handling dynamic. Using our own customized unstructured finite element solver written in MATLAB, our resulting spatio-temporal model further studies impact of variant spatial distributions of MT Ca2+ transporters and MT themselves. This study also gives insights into the overall role of MT in modulating cytosolic Ca2+ signals, crucial to behavior of other cellular mechanisms ranging from cardiac cell contraction to neurotransmitter release.

Complex behavior in a dengue model with a seasonally varying vector population

A/Prof. Geoffry Mercer, Timothy McLennan-Smith
National Centre for Epidemiology and Population Health
Australian National University
Geoff.Mercer@anu.edu.au
4:00 pm Monday

In recent decades, dengue fever and dengue hemorrhagic fever have become a substantial public health concern in many subtropical and tropical countries throughout the world. Many of these regions have strong seasonal patterns in rainfall and temperature which are directly linked to the transmission of dengue through the mosquito vector population. Our study focuses on the development and analysis of a strongly seasonally forced, multi-subclass dengue model. Analysis of this model focuses particularly on the existence of deterministic chaos in regions of the parameter space which potentially hinders application of the model to predict and understand future outbreaks.

Modelling Wave Attenuation in the Marginal Ice Zone

Dr Mike Meylan
School of Mathematical and Physical Sciences
The University of Newcastle
mike.meylan@newcastle.edu.au
3:20 pm Monday

The marginal ice zone forms at the boundary between the open ocean and the frozen pack ice. It is an inter-facial region which is subject to intense wave action, and this wave action is thought to play a critical role in determining the break-up of the pack ice. At present, the process of wave induced break-up is poorly understood, in part because of the extreme difficulty of making measurements, and in part because of the difficulty of modelling the complex scattering process. A number of different models have been proposed and I will discuss and compare these. I will also present possible methods to combine them and discuss some of the important open modelling problems

Mathematical modelling of salt and water uptake and transport in plant roots

Prof. Stan Miklavcic, Kylie Foster
Phenomics and Bioinformatics Research Centre, School of Information Technology and Mathematical Sciences
University of South Australia
Stan.Miklavcic@unisa.edu.au
4:20 pm Wednesday

High salinity affects one-fifth of the world's irrigated land and two-thirds of Australian cereal crops. Modelling the uptake of water and ions by plants will improve our understanding of the biophysical mechanisms responsible for a plant's salinity tolerance. The root is responsible for the uptake of water and mineral nutrients, as well as mineral toxins, from the soil and initiates the transport of these into the rest of the plant. A discretised, time-dependent, model of water and ion flow in the young root of a plant is presented. The transport processes included in the model are diffusion, driven by both concentration gradients and electrostatic potential gradients, and convection, due to both hydrostatic and osmotic pressure differences. We present and discuss the results of our simulations highlighting the effects of the many competing factors. We conclude with directions for future work.

Ducks on Drugs: Folded saddle canards in a model of propofol anaesthesia

Mr John Mitry†, Michelle McCarthy, Nancy Kopell, Martin Wechselberger
Mathematics and Statistics
University of Sydney
john.mitry@gmail.com
10:20 am Tuesday

We investigate firing threshold manifolds in a mathematical model of an excitable neuron. The model here analysed investigates the phenomenon of post-inhibitory rebound spiking due to propofol anesthesia. Propofol modulates the decay time-scale of an inhibitory GABAa synaptic current. Interestingly, this system gives rise to rebound spiking within a specific range of propofol doses.

Using techniques from geometric singular perturbation theory we identify geometric structures, known as canards of folded saddle type, which form the firing threshold manifolds. We find that the position and orientation of the canard separatrix is propofol dependant. Thus the speeds of relevant slow synaptic processes are encoded within this geometric structure. We show that this behaviour cannot be understood using a static, inhibitory current step protocol, which can only provide a single threshold for rebound spiking but cannot explain the observed cessation of spiking for higher propofol doses.

Time permitting, we shall then compare the analyses of dynamic and static synaptic inhibition, showing how the firing threshold manifolds of each relate, and why a current step approach is unable to fully capture the behaviour of this model.

Operations research extracting response to antiviral therapy for hepatitis C virus envelope sequences

A/Prof. John Murray, R. Moenne-Loccoz, T. Baumert, E. Schvoerer
School of Mathematics and Statistics
University of New South Wales
j.murray@unsw.edu.au
10:00 am Tuesday

The poor response to standard of care antiviral therapy of pegylated alfa-interferon and ribavarin for hepatitis C virus (HCV) infection is likely linked to mutations in the viral envelope gene E1E2, which can result in escape from the immune response and higher efficacy of viral entry. Mutations that result in failure of therapy most likely require compensatory mutations to achieve sufficient change in envelope structure and function. Genotype 1 virus exhibits the poorest response rates of approximately 50%. We assessed mutational networks in E1E2 sequences that differentiated sustained virological response (SVR) from non-response (NR) in 43 genotype 1a (17 SVR), and 49 genotype 1b (25 SVR) chronically HCV-infected individuals, calculating covarying pairs of amino acids (aa) over the 555 long aa sequences. The covarying networks, where covarying pairs formed the edges of the network, were more highly connected for 1a than for 1b, consistent with the different clustering within their phylogenetic trees.

There were many subnetworks that exhibited aa combinations that appeared in SVR but not in NR individuals, and hence separated response groups. Our aim was to determine the major features that were associated with response. We formulated this separation problem over covarying networks using binary integer programming and extracted optimal networks that achieved this goal. Between 5 and 9 aa pairs were required to separate response groups indicating that a number of changes are required in the viral envelope for evasion of the immune response and antiviral therapy. aa in hypervariable region 1 were 6 times more likely than chance to occur in the optimal networks. This work represents a novel application of operation research methods.

Brood, food and collapse: A delay differential equation model for honey bee demography.

A/Prof. Mary Myerscough, David Khoury
School of Mathematics and Statistics
University of Sydney
mary.myerscough@sydney.edu.au
1:00 pm Tuesday

Honey bee hives become depopulated and die when forager survival becomes too low but the forager death has implications not only for the number of adult bees in the hive but also for the amount of food that the hive can collect and store and the number of brood that it raises to adult hood.

In this talk, we extend an earlier model that only included adult bees to include explicitly the role of food in maintaining hive health. As part of this we must include uncapped brood (eggs and larvae) as uncapped brood is not only a major consumer of food but is also cannabalised by adult bees in response to food shortage.

If 100% of the bees survive pupation to become adults, we can model the populations of uncapped brood, hive bees and foragers and food dynamics as a system of four differential equations with a delay. The model predicts that for mid-range rates of forager death, the hive population will be limited by food availability. It also predicts that a hive can die while it still has stored food in the hive, which is a very common symptom of colony collapse disorder.

Adaptive radial basis function for time-dependent partial differential equations by reconstruction through cubic splines

Mrs Syeda Laila Naqvi†, J. Levesley , S.L Naqvi
Mathematics
University of Leicester, UK
lnn2@le.ac.uk
3:20 pm Wednesday

To improve the quality of a given initial approximation which is based on the linear combination of certain basis functions a classical technique is to adaptively select the number of basis functions used for the fit. The selection is based on refining and coarsening of the nodes.

We developed a method using the grid free property of the Radial Basis functions which adaptively refine and coarse the nodes to obtain a numerical solution such that the error is below a prescribed accuracy but with the smallest number of degrees of freedom.

The adaption merely rely on the error indicator and the reconstruction is done by cubic splines for non-linear time-dependent Partial differential equations.

The performance of the method is shown in numerical examples for one dimensional case.

Dengue and mosquitoes: can we stop transmission?

Mr Meksianis Zadrak Ndii†
Computer Assisted Research Mathematics and its Application
The University of Newcastle
meksand@gmail.com
10:20 am Monday

Dengue is a vector-borne disease that has become a public health concern worldwide. The conventional strategies are non-sustainable due to increasing resistance, cost and manpower requirements. Therefore, an alternative strategy is required.

A promising effective strategy is through Wolbachia intervention. Wolbachia is a bacterium that naturally infects most insects, but not the main dengue vector, Aedes aegypti. Wolbachia out-competes the dengue virus in the saliva gland of the mosquito, hence reducing the probability of transmission of dengue from mosquitoes to humans. Experimental and field trials for the release of Wolbachia-infected mosquitoes have been conducted in Queensland Australia. However, research questions arise from these trials that mathematical modelling can help answer. For example, how likely are Wolbachia-infected mosquitoes to persist in competition with non-Wolbachia mosquitoes? By how much is dengue transmission likely to be reduced due to the Wolbachia intervention? We develop mathematical models towards the goal of answering these questions.

The biological treatment of wastewater: modelling a sludge disintegration unit

Dr Mark Nelson, Rubayyi Turki Alqahtani
School of Mathematics and Applied Statistics
University of Wollongong
mnelson@uow.edu.au
10:40 am Thursday

One of the main disadvantages of the activated sludge process is that it produces a large amount of sludge. Disposal of the sludge can account for 50-60

Yoon developed a model for a membrane bioreactor system (MR) attached to a SDU. This model assumes that the process of sludge disintegration occurs infinitely quickly, so that the operation of the SDU is modelled by two algebraic equations. The resulting MR-SDU system can be analysed by finding the steady-states of the model and determining their stability as a function of the residence time. If the sludge disintegration factor is sufficiently high then the amount of sludge content in the MBR is guaranteed to be below the target value. (This has the potential to lead to significant reductions in operating costs).

How crucial is the assumption that the processes in the SDU occur infinitely quick? What happens if they occur at a finite rate? How sensitive is the critical value of the sludge disintegration factor to a finite rate? To answer these questions we need a model in which sludge disintegration occurs at a finite rate. In the process of writing down such a model we discover that the Yoon model is incorrect because it is not the correct limit as the 'rate' goes to infinity. Is it important that the Yoon model is incorrect?

Phase-Type Poisson distributions (like Poisson, but different)

Giang Nguyen, Guy Latouche, Sophie Hautphenne
The University of Adelaide
giang.nguyen@adelaide.edu.au
10:40 am Monday

Phase-Type Poisson distributions may be examined from different perspectives. Matrix-form Poisson distributions were first introduced in Wu and Li (2010) as one generalization of Panjer distributions, and subsequently analyzed in Siaw et al (2011). The main focus of these two papers was to extend Panjer's algorithm—an efficient recursive procedure for evaluating compound distributions, assuming that the number of summands follows a Panjer distribution—to more general families of distributions, including the Matrix-form Poisson distributions. Here, we show that when certain positivity constraints are satisfied, these Matrix-form Poisson distributions have a physical interpretation as extensions of Phase-Type distributions. We refer to these positive Matrix-form Poisson distributions as Phase-Type Poisson distributions, and use our physical interpretation to construct an EM algorithm for parameter estimation.

A multilevel algorithm for box integrals on string generated Cantor sets

Dr Dirk Nuyens
Department of Computer Science
KU Leuven
dirk.nuyens@cs.kuleuven.be
12:20 pm Tuesday

We discuss the standard multilevel Monte Carlo algorithm which was popularized by Giles (2008) for the evaluation of a functional over a discretized SDE path. But here we are interested in box integrals, e.g., the expected distance between two points, over a Cantor set (see, e.g., Bailey, Borwein, Crandall and Rose). This is to say, the points are members of a string generated Cantor set, embedded in standard d-dimensional space. The members of such a Cantor set can be defined recursively (in base 3) and then lead, in a way, to infinite-dimensional integrals for which different resolutions could be mapped to different levels to which we finally apply the multilevel algorithm.

Using network science to explore innovation

Dr Dion O'Neale
Applied Mathematics
Industrial Research Ltd
d.oneale@irl.cri.nz
1:00 pm Monday

We live in a world were scientific and technical advances increasingly require more specialised expertise while using contributions from ever more diverse technical areas. At the same time, resources for research and development grow ever tighter and funding is increasingly focused on targeted outcomes. In an effort to better understand the relationships

between different areas of innovation and the role of specialisation in national and regional economies, we have mined several million patent records from the European Patent Office along with their classification codes.

By identifying when individual regions have a "revealed comparative advantage" with respect to particular technical areas, we have been able to construct a proximity network or "base map" for the space of patentable innovation. This allows us to use techniques from network science, such as community detection, to explore the space of innovation. We find that "patent-space" is heterogeneous and highly structured; overlaying data on the patent-space base map we are able to explore temporal and regional trends. We will discuss how the mathematical techniques employed in this work can be used to better understand how innovation occurs and how they might be able to inform decisions such as determining strategic areas for science investment.

Sparse and stable spectral methods

Dr Sheehan Olver, Alex Townsend
School of Mathematics and Statistics
The University of Sydney
Sheehan.Olver@sydney.edu.au
5:20 pm Wednesday

We construct a spectral method based on Chebyshev and ultraspherical polynomials, applicable to low and high order linear ODEs with variable coefficients and general boundary conditions. The matrices of this spectral method are almost banded and have bounded condition number. The structure of the matrices allow for a scheme that grows only linear in the degrees of freedom, where the optimal truncation is determined automatically, allowing us to easily solve equations that require over a million unknowns. We further adapt the approach to PDEs by formulating the problem as a Sylvester's equation.

Non-equilibrium thermodynamics of folding in geomaterials

Mr Martin Paesold†, Andrew Bassom, Ali Karrech, Bruce Hobbs, Alison Ord
School of Mathematics and Statistics
University of Western Australia
21102578@student.uwa.edu.au
5:40 pm Monday

For the efficient exploration, management and production of natural resources it is of importance to understand the formation of resource deposits thoroughly. Our work treats the forming resource deposit as a dynamical system. It focuses particularly on folding as the concentration of minerals is related to folds. In geosciences, the most accepted theory to describe folding is Biot's theory. This theory predicts an exponential growth of folds with a certain wavelength under external loading and this dominant wavelength depends on material properties. In contrast to the features that are found in nature, Biot's theory predicts solely sinusoidal folds and neglects the non-equilibrium aspects of folding. Our work incorporates non-equilibrium aspects and combines numerical and analytical techniques. Multi-process physics of folding combined with large deformations of materials is simulated using the finite element method. Based on these simulations, the key processes that govern the overall folding dynamics of geomaterials can be identified and mathematical models can be constructed. Successively, these models will be analyzed with standard tools from bifurcation theory. This talk will give a review of the existing literature and outline the thermodynamics of deformations in geomaterials. The novel aspects of the numerical studies that are utilized in our work and how they complement the mathematical analysis will be described in detail. Recent results will be presented.

Some novel diffusion-driven flows

A/Prof. Michael Page
School of Mathematical Sciences
Monash University
michael.page@monash.edu
10:20 am Monday

Independent studies by Wunsch and Phillips in 1970 showed that steady flow can be generated in a stable density-stratified fluid simply due to the container having sloping insulated surface. Most of the analysis for this type of problem has been performed in two-dimensional containers with uniformly sloping planar surfaces but insulating surfaces with a varying slope can also lead to interesting effects. A simple example is the circular container considered by Quon (1989, J. Fluid Mech., 202, p201), who proposed an analytical solution for the forced flow at large Rayleigh number - albeit one that seems to be incorrect.

In this talk, a complete and consistent asymptotic structure for Quon's circular container problem is outlined in that same limit. Leading-order solutions are described, including within a new type of region near the top and base of the cylinder. These analytical results are compared with numerical results at small R (or large Rayleigh number) for some different types of flow forcing.

A Production-Inventory System with Disruption and Reliability Considerations

Mr Sanjoy Kumar Paul†, Ruhul Sarker, Daryl Essam
School of Engineering and Information Technology
University of New South Wales, Canberra
Sanjoy.Paul@student.adfa.edu.au
1:00 pm Wednesday

In this research, a two-stage batch production-inventory system is introduced where the production may be disrupted, for a given period of time, either at one or both stages. For this system, the mathematical models have been developed considering single item production as well as multiple items production in cyclic order. The process reliability is assumed to be an important factor because of the imperfect production environment. The formulated model belongs to the class of constrained non-linear optimization programming which is solved using genetic algorithm and pattern search techniques. The results of the two algorithms have been compared, and the numerical examples are presented to demonstrate the usefulness of the model.

Collective motion of dimers

Catherine Penington†, Karolina Korvasova, Barry D. Hughes, Kerry A. Landman
Mathematics and Statistics
University of Melbourne
c.penington@student.unimelb.edu.au
12:40 pm Monday

Most agent-based models of cell movement assume that agents are points in space or circular: we consider instead a discrete agent-based model on a one-dimensional lattice and one a two-dimensional square lattice, where each agent is a dimer occupying two sites. Agents move by vacating one occupied site in favour of a nearest-neighbour site, and obey either a strict simple exclusion rule or a weaker constraint that permits partial overlaps between dimers. In the continuum limit, nonlinear diffusion equations that describe the average agent occupancy are obtained, and solutions of these compare very well with average discrete simulation data. Since many cell types are elongated in one direction, this work offers insight into population-level behaviour of collective cellular motion. Based on a paper recently published in Physical Review E.

Accurate numerical simulations of three-dimensional ship wave patterns.

Ravindra Pethiyagoda†, Scott McCue
mrpacho@gmail.com
1:00 pm Monday

The talk is concerned with computing steady three-dimensional ship wave patterns that form when a uniform stream flows past a point source. Flows of this sort are of great interest to the design of ship hulls or submarines, for example. By applying a boundary integral approach, the nonlinear free surface problem is reduced to an integral equation in two spatial dimensions, which is solve together with a Bernoulli-type boundary condition on the unknown fluid surface. The problem is discretised into a system of non-linear algebraic equations which is solved using Newton's method and variants. We concentrate on applying a preconditioned Jacobian-free Newton-Krylov (JFNK) method and show results that are much more efficient and accurate than those presented in contemporary literature.

Generalized Distance and fuzzy Concepts for Fixed Point Problems in metric spaces

Dr Narin Petrot
Department of Mathematics, Faculty of Science
Naresuan University
narinp@nu.ac.th
10:20 am Wednesday

In this work, the concepts of a set-valued contractive mapping are considered in metric spaces, by using the idea of generalized distances, as τ-distance. The existence theorems for fixed points of those two concepts are provided. Also, by using the concept of a class of functions, as we will call $\mathcal{R}$ -function, we provide some fixed point theorems on a space of fuzzy sets, under the supremum metric. Some interesting cases are also discussed.

Rapidly Rotating Anisotropic α-effect Dynamos

Dr Collin Phillips, D. J. Ivers
Mathematics Learning Centre
University of Sydney
collin.phillips@sydney.edu.au
12:40 pm Monday

Mean field $\boldsymbol{\alpha}^2$-dynamos in a sphere with an insulating exterior are considered for a steady α-effect of the form $\boldsymbol{\alpha} = a(\mathbf{I} - A\hat{\mathbf{z}}\hat{\mathbf{z}})$, $A \geq 0$, derived by Moffatt (1970) for strong rotation. The unit vector $\hat{\mathbf{z}}$ is aligned with the angular velocity $\boldsymbol{\Omega}$ and as $\Omega \to \infty$, $A \to 1$. We consider the effect on axisymmetric magnetic fields as the rotation rate is increased, i.e. $A \to 1$, so that the $\boldsymbol{\alpha}$-effect varies from isotropic to anisotropic, for two models: $a = r\cos\theta$ and $a = \cos\theta$. We find that both equatorially symmetric and antisymmetric critical solutions bifurcate from steady to oscillatory at some value of $A \in (0, 1)$. The bifurcation is associated with the poleward migration of strong magnetic field, leaving a region of weak field near the equator which increases with the rotation rate. No antidynamo action was found at the fast rotation limit $A = 1$.

So long and thanks for all the fish

Dr Mike Plank
Department of Mathematics and Statistics
University of Canterbury
michael.plank@canterbury.ac.nz
12:40 pm Wednesday

Overfishing is a worldwide problem. More than half the worlds population is dependent on fish for part of their diet, yet many fish stocks have been depleted to dangerously low levels. Most commercial fisheries have strict regulations on the size and species of fish that can be targeted, usually prohibiting the landing of fish under a minimum legal size. However, this strategy is coming under increasing criticism and it has been suggested that a more balanced approach, in which fishing effort is spread over a wide range of sizes and species, could be beneficial. In this talk, I will present a size-spectrum model, based on a PDE for the abundance of individuals of size x at time t. I will use this model to compare the traditional minimum catch size approach to fisheries management with the alternative balanced harvesting. The results show that balanced harvesting can give improvements in sustainable yield with reduced risk of stock collapse. I will discuss how these results fit with available empirical data.

Existence theorems for the n-vectorial saddle point problems

Prof. Dr. Somyot Plubtieng, Kanokwan Sitthithakerngkiet
Department of Mathematics, Faculty of Science
Naresuan University
somyotp@nu.ac.th
10:00 am Thursday

In this paper, we introduce the n-vectorial saddle point problem (for short VSP_n) which defined on n-dimensional saddle point where $n > 2$ by focusing only on the saddle point of order one. For that matter, we prove existence saddle point of (VSP_n) under assuming compactness and uncompactness by using Fan- KKM Theorem. This result improves and extends some literatures on the existence theorems of saddle point problems.

Demand Driven Throughput Assessment for Hunter Valley Coal Chain

Mr Mohsen Reisi†, Natashia Boland, Martin Savelsbergh
School of Mathematical and Physical Science
The University of Newcastle
m.reisi@gmail.com
10:00 am Wednesday

Hunter Valley Coal Chain (HVCC) is the largest coal export operation in the world. It includes transporting coal from over 40 mines located in the Hunter Valley area to the port of Newcastle in New South Wales, Australia. The port of Newcastle serves approximately 1200 vessels and export more than 100 million tonnes of coal per year. The system that supports this operation is a collection of mines, rail tracks, trains, and port terminals. One of the most important and far-reaching decision problems is long-term capacity planning. As the demand for coal continues to grow, coal export through Newcastle is expected to increase in the near future. Therefore system analysis plays a crucial role to understand the needs of the system in the future. This research introduces an integer programming-based methodology to assess the throughput in a short amount of time. In this work, first, an integer programming model is introduced for HVCC, and then an alternative model is suggested with several strategies to reduce the size of the problem and provide stronger constraints. Second, the IP model is used as a tool to analyze the throughput of the system using some metrics to see how the system reacts under different scenarios.

How epidemiology interacts with ecology

Prof. Mick Roberts
IDReC, INMS and NZIAS
Massey University
m.g.roberts@massey.ac.nz
12:20 pm Tuesday

A differential equation model describes how infectious diseases may alter the interactions between populations in a complex food web. Two simple examples will be used to illustrate this approach. The first of these is a model of the rinderpest, wildebeest, grass interaction, where the inferred dynamics qualitatively match the observed phenomena that occurred after the eradication of rinderpest from the Serengeti ecosystem in the 1980s. The second example is a prey-predator system, where both species are hosts of the same pathogen. It is shown that regions for the parameter values exist where the two host species are only able to coexist when the pathogen is present to mediate the ecological interaction.

A new approach supports slowly varying and thin layer PDE models

Prof. Tony Roberts
School of Mathematical Sciences
University of Adelaide
anthony.roberts@adelaide.edu.au
4:40 pm Wednesday

The slowly varying or thin layer assumption empowers understanding of many physical processes from dispersion in pipes and rivers, including beams, shells, and the modulation of nonlinear waves, to homogenisation of micro-structures. Yet extant theoretical support is limited—especially when making forecasts and on finite domains. I introduce a new approach to theoretical support using perhaps the simplest example of slowly varying dynamics: we will explore the dynamics of an ideal heat exchanger with some nonlinear reaction. The approach proves the accuracy of mixed order local models, with a precisely quantified local error (in principle). The approach potentially caters for boundary conditions and general 'cylindrical' systems.

Topology optimization for bone implants and high strength to weight ratio cellular materials

Dr Tony P Roberts, V. Challis, T. Sercombe, J. Grotowski
Mathematics
UQ
apr@maths.uq.edu.au
11:00 am Thursday

We discuss topology optimization in the context of designing optimal three-dimensional bone implant scaffolds which jointly optimize stiffness and pore space diffusivity. The stiffness is constrained to be elastically isotropic to avoid weakness in any direction of loading. We describe the process for fabricating Titanium alloy scaffolds at multi-millimetre scales, and show that the scaffolds have excellent strength- and stiffness- to weight ratios.

Expectations on Fractal Sets

Mr Michael Rose†, Jon Borwein, David Bailey, Richard Crandall
CARMA
University of Newcastle
michael.rose@newcastle.edu.au
4:20 pm Wednesday

Motivated by laboratory studies on the distribution of brain synapses, the classical theory of box integrals - being expectations on unit hypercubes - is extended to a new class of fractal String-Generated Cantor sets. For such SCSs, a suitable choice of generating string allows for

fine-tuning the fractal dimension of the corresponding set. Closed forms for certain statistical moments on these fractal sets will be presented, together with a precision algorithm for higher embedding dimensions.

How big is an outbreak likely to be?

Dr Joshua Ross, Thomas House, David Sirl
School of Mathematical Sciences
University of Adelaide
joshua.ross@adelaide.edu.au
5:40 pm Monday

Epidemic models have become a routinely used tool to inform policy on infectious disease. The final size of an epidemic can be defined informally as the total number of people experiencing infection during the outbreak. It turns out that there is a particularly large number of approaches that may be used to calculate the probability mass function for the final size of an epidemic. I will discuss some of these approaches.

Accurate solution to the scattering problem for arrays of infinitely long cylinders

Dr Galyna Safonova
PBRC, School of Information Technology and Mathematical Sciences
University of South Australia
galyna.saf@gmail.com
10:20 am Monday

The mathematically rigorous method for solution of 2-D scattering problems for arbitrarily profiled cylinders is developed. In the core of our approach lies the idea of analytical regularization of integral equations containing singularities. The proposed regularization technique reduces them to infinite system of algebraic equations of the second kind. The resulting equation is well-conditioned and can be effectively solved by the truncation method.

The constructed fast and reliable algorithm is applied to the analysis double-layered infinitely long arrays. This analysis confirmed a possibility of powerful resonant response of a chain of coupled resonator cells that should be considered when designing practical devices incorporating the double- (or multi-) layer finite arrays with volumetric elements. Generally numerical methods do not allow one to determine the high Q factor oscillations with much accuracy. By contrast, our developed method allows the stable and accurate computation across various wavenumber intervals including the resonance points.

A new algorithm for solving bi-objective 0-1 integer programs

Prof. Martin Savelsbergh, Hadi Charkhgard, Natashia Boland
School of Mathematical and Physical Sciences
University of Newcastle
martin.savelsbergh@newcastle.edu.au
10:20 am Thursday

Large-scale single-objective 0-1 integer programs are routinely and reliably solved in many industry sectors due to the availability of sophisticated, powerful commercial solvers. Unfortunately, the situation is quite different when it comes to solving multi-objective 0-1 integer programs. Few, if any, algorithms exist that efficiently and reliably produce all non-dominated solutions, i.e., the complete efficient frontier. We have developed a novel approach for efficiently producing all non-dominated solution for bi-objective 0-1 integer programs, using a simple scheme for partitioning the objective function space and exploiting the power and features of modern 0-1 integer programming solvers. Computational experiments demonstrate the efficacy of the approach.

Mathematical modelling in anti-HIV gene therapy: estimating clinically relevant parameters and predicting likely clinical outcomes

Dr Borislav Savkovic, Scott Ledger, Geoff Symonds, John M Murray
Mathematics and Statistics
The University of New South Wales
b.savkovic@unsw.edu.au
10:40 am Monday

Gene therapy represents a promising modality to treat HIV/AIDS. The concept involves the introduction of an anti-HIV gene into a patients immune cells, thereby conferring protection against the HIV virus. While in-vitro and humanized mice studies, by our group and others, have demonstrated strong anti-viral effects of the therapy, it is the translation of this therapy into clinical practice that represents current challenges. In this talk, I will outline how mathematical modelling is

providing a clearer understanding of the quantitative factors involved in the delivery of such gene therapy in-vivo, with the aim of maximizing therapeutic effect against HIV. This work is funded by an ARC Linkage Grant and is in collaboration with the industry partner Calimmune Australia Pty Ltd.

Rules of attraction, repulsion, orientation and streaking a model for the guidance and motion of honey bee swarms

Dr Timothy Schaerf, Darcy R Gray, Mary R Myerscough, Madeleine Beekman
School of Mathematics and Statistics and School of Biological Sciences
University of Sydney
timothy.schaerf@sydney.edu.au
12:40 pm Tuesday

During the spring, honey bee colonies issue reproductive swarms that go on to form new colonies. Initially the swarms form a hanging cluster close to their old homes. A small proportion of the swarm, the scouts, then explore the local surroundings to find and assess potential sites for a new home. Once a new home is chosen, knowledgeable scouts have the additional task of guiding naive members of the swarm to the new nest site. It is generally thought that the knowledgeable scouts guide the swarm by flying rapidly through the upper portion of the swarm in the direction of their target (streaking) before dropping down to the lower sections of the swarm, flying slowly to the trailing edge of the swarm and then returning to the top of the swarm to streak again. The streakers are likely to number less than 100, whereas a swarm could be comprised of up to 15000 bees. I will use a well established individual based model for collective animal motion where individuals interact with each other based on simple rules for repulsion, orientation and attraction to examine swarm guidance by streaking honey bees.

L^1-Regularization of Linear-Quadratic Control Problems

Christopher Schneider†, Walter Alt
Friedrich-Schiller-University Jena
Mathematical Optimization
Christopher.Schneider@uni-jena.de
1:00 pm Tuesday

We analyze L^1-regularizations of a class of linear-quadratic optimal control problems with control appearing linearly. This leads to a nonsmooth cost functional:

$$\begin{aligned}
&\min\ \tfrac{1}{2}x(t_f)^\top V x(t_f) + \int_0^{t_f} \tfrac{1}{2}x(t)^\top W(t)x(t) + w(t)^\top x(t) + r(t)^\top u(t)\,\mathrm{d}t + \beta\|u\|_{L^1}\\
&\text{s.t.}\ \ \dot{x}(t) = A(t)x(t) + B(t)u(t) \quad \forall' t \in [0, t_f]\,,\\
&x(0) = a\,,\\
&u(t) \in U := \{u \in \mathbb{R}^m \mid b_\ell \le u \le b_u\} \quad \forall' t \in [0, t_f]\,.
\end{aligned}$$

To deal with the nonsmooth problem we use an augmentation approach (see (2)) in which the number of control variables is doubled. It is shown that if the optimal control is bang-bang, the solutions are continuous functions of the regularization parameter β. We also show that the optimal controls for $\beta = 0$ and a sufficiently small $\beta > 0$ coincide except on a set of measure $\mathcal{O}(\beta)$. Since the minimum principles give the same results for both the original problem and the augmented one we use the Euler discretization to solve the augmented problem. Then we can refer to (1) for error bounds of the approximation.

(1) W. Alt, R. Baier, M. Gerdts and F. Lempio, Error bounds for Euler approximation of linear-quadratic control problems with Bang-Bang solutions, Numerical Algebra, Control and Optimization 2 (2012), 547–570.

(2) G. Vossen and H. Maurer, On L^1-Minimization in optimal control and applications to robotics, Optimal Control Applications and Methods 27 (2006), 301–321.

Modelling South Australian Motor Vehicle Emissions and Exposure Risk Analysis

Miss Lisa Schultz†, Dr. Belinda Chiera, Dr. Pushan Shah, Prof. John Boland
School of Mathematics and Statistics
University of South Australia
lisa.schultz@mymail.unisa.edu.au
10:20 am Wednesday

Recent studies in the area of motor vehicle emissions have shown such emissions to be a domi- nant contributor to ambient anthropogenic pollution in the atmosphere. The detrimental health effects of exposure, and proximity, to vehicle exhaust pollution have been well-established and form the focus of efforts to mitigate vehicle exhaust pollution exposure through the develop- ment of strategies to reduce pollution emissions. These issues are of high interest and crucial importance in today's society, particularly for urban populations residing near major roadways.

The research presented here focuses on modelling motor vehicle emissions, measured from the second National In-Service Emissions (NISE2) study, as functions of vehicle speed, for a selection of vehicle categories and road types to produce new South Australian emission factors. The NISE2 emissions data has been modelled using local polynomial regression techniques. The exposure of urban South Australian residents to vehicle exhaust pollution will be investigated through a case study analysis for a selection of major roads in Adelaide, South Australia.

Our research will provide a strong understanding of the approximate pollution concentra- tions and movement in the South Australian air shed and will form a solid platform on which we will base informed strategies for exposure mitigation and recommendations for emission re- duction. Future work will see these emission factors incorporated into the South Australian Motor Vehicle Emissions Inventory model. Our strategies and recommendations will also be suitable for incorporation into future air quality management decisions as well as current strate- gies for pollution control and abatement, including Australia's National Plan for Clean Air, a nation-wide strategic approach to air quality management, currently in development.

Propagation and stability of vortices in bounded nonlocal nonlinear media

Luke Sciberras†, A.A. Minzoni, N.F. Smyth and A.L. Worthy
School of Mathematics and Applied Statistics
University of Wollongong
lws31@uowmail.edu.au
10:40 am Monday

Background information into and reasons for using polarised light beams (lasers) to form solitons (or optical waves) in a liquid crystal will be initially discussed in this talk. Extending from this, there will be an examination of a specific type of optical wave called an optical vortex and a brief discussion of its formation. Using this background knowledge along with variational techniques and Lagrangian methods in a nonlinear system of PDE's, conversations will be directed towards a study on the evolution of an optical vortex in a finite nematic liquid crystal cell. Indeed, this study requires linearised stability analysis about the steady state for the given system to determined a relationship between the instability of an optical vortex and the minimum distance of approach to the boundary. Results from the mathematical study, show that the simple asymptotic approximations capture the amplitude of the optical vortex and its path towards its final steady state within a finite cell. The variational analysis results are compared to the full numerical solution for the nonlinear system. Good agreement is shown with all results.

An Implicit Discretization Scheme for Linear-Quadratic Control Problems with Bang-Bang Solutions

Martin Seydenschwanz†, Martin Seydenschwanz
Friedrich-Schiller-Universitaet Jena
Department of Mathematics and Computer Science
martinsey@gmx.de
3:40 pm Monday

In order to obtain an approximate solution, optimal control problems are usually discretized employing Euler or more general Runge-Kutta discretization schemes. For the analysis of the discretization error it is often assumed, that the optimal control is at least Lipschitz continuous. First results on the error analysis for bang- bang controls can be found in (6). In (1), (2) (see also (3)) Euler discretizations for a class of linear-quadratic control problems with bang-bang solutions have been investigated, by using a second-order condition due to Felgenhauer (4). Since Euler discretizations become unstable when solving stiff differential equa- tions, a stable, implicit discretization scheme should be used in practice. In (5) such a scheme using collocation methods has been utilized for the numerical solu- tion of optimal control problems. We will derive error estimates for this implicit discretization scheme applied to the linear-quadratic control problem

$$(OQ) min f(x,u) s.t. \dot{x}(t) = A(t)x(t) + B(t)u(t) a.e. on [0,T], x(0) = a u(t) \in U a.e. on [0,T],$$

with bang-bang solutions. To this end we extend the proof techniques for Euler discretizations developed in (1) and (2). Moreover, we consider a more general class of control problems by adding mixed state-control terms to the cost functional. In our main result we show that any discrete optimal control u h coincides with the optimal control u of (OQ) except on a set of measure $O(\sqrt{h})$. Additionally, we prove convergence of order 1/2 w.r.t. the mesh size for the states and adjoint states. Finally the theoretical findings will be illustrated by a numerical example.

(1) W. Alt, R. Baier, M. Gerdts and F. Lempio, Approximations of linear control problems with bang-bang solutions, Optimization, DOI: 10.1080/02331934.2011.568619 (2011).

(2) W. Alt, R. Baier, M. Gerdts and F. Lempio, Error bounds for Euler approximation of linearquadratic control problems with Bang-Bang solutions, Numerical Algebra, Control and Optimization 2 (2012), 547570.

(3) W. Alt and M. Seydenschwanz, Regularization and Discretization of Linear-Quadratic Control (4) U. Felgenhauer, On stability of bang-bang type controls, SIAM J. Control Optim. 41 (2003), 18431867.

(5) O. von Stryk, Numerische Losung optimaler Steuerungsprobleme: Diskretisierung, Parameteroptimierung und Berechnung der adjungierten Variablen, Fortschr.-Ber. VDI Reihe 8 Nr. 441. Dusseldorf: VDI-Verlag 1995.

(6) V. M. Veliov, Error analysis of discrete approximations to bang-bang optimal control problems: the linear case, Control Cybernet. 34 (2005), 967982. Friedrich-Schiller-Universitat Jena, 07740 Jena, Germany

Modelling dynamic fire spread mechanisms

Dr Jason Sharples, Colin Simpson, Jason Evans, Matthew McCabe, Rick McRae
UNSW Canberra
j.sharples@adfa.edu.au
10:00 am Thursday

Catastrophic wildfires are global phenomena that consistently result in loss of life and property, and further impact the cultural, economic and political stability of communities. Dynamic interactions between strong winds, terrain and an active fire have been shown to cause rapid growth of bushfires and the subsequent onset of extreme pyro-convection. This presentation will focus on a particular form of atypical fire spread that results from such interactions, and will present recent modelling results that elucidate the physical processes driving it.

Pricing bond options under a Markovian regime-switching HullWhite model

Mr Yang Shen†, Tak Kuen Siu
Department of Applied Finance and Actuarial Studies
Macquarie University
skyshen87@gmail.com
5:40 pm Monday

In this paper, we investigate the valuation of bond options under a Markovian regime-switching HullWhite model, where both the mean-reverting level and the volatility of the interest rate are modulated by a continuous-time, finite-state Markov chain. Using techniques of measure changes and the inverse Fourier transform, we obtain an integral representation for the pricing formula of a standard European option on a zero-coupon bond. Numerical results for the prices and implied volatilities of bond options arising in our model are given in a two-regime case.

Challenges in Numerical Relativity

Ms Chaitanya Shettigara†
Mathematical Sciences Institute
Australian National University
chaitanya.shettigara@gmail.com
4:40 pm Monday

Einstein's theory of general relativity leads to predictions that are not present in classical physics. Many of these have been validated through experiment, with the notable exception of gravitational waves. The detection of gravitational waves is difficult because of the tiny effect they have on detectors. However, with the next-generation gravitational wave detector Advanced LIGO due to be operational in late 2013, it is expected that direct observation is just around the corner.

An important step in gravitational wave detection is modelling gravitational wave sources. Owing to the complexity of Einstein's field equations, this is performed using numerical methods and presents a significant computational and mathematical challenge. In this talk I will discuss the challenges faced in modelling extreme mass ratio binary black hole inspirals, in particular how to evaluate errors in these complex systems and an investigation of where existing codes break down.

Travelling waves in a competitive reaction scheme

A/Prof. Harvi Sidhu, Wilson Wee, Jason Sharples and Vladimir Gubernov
School of PEMS
UNSW Canberra
h.sidhu@adfa.edu.au
12:20 pm Monday

Studies of exothermic reaction fronts are of interest to science and industry; they form the basis of a combustion or reaction wave and find relevant applications in the synthesis of advanced materials, the design of explosives and power generation. To date, most mathematical investigations of the properties of exothermic reaction fronts have only utilised the simplest models with one-step chemistry, where the reaction is assumed to be well-modelled by a single-step reaction of the fuel and oxidant to become products and heat. However, models with two-stage reaction kinetics have been less comprehensively studied, especially in a competitive scheme where it is possible for two thermally and chemically coupled reactions to feed on the same reactant, releasing heat and absorbing heat via their respective endothermic and exothermic pathways.

In this work we numerically derive the properties of reaction fronts arising in a pre-mixed two-staged competitive exothermic-endothermic reaction scheme where both reaction pathways are competing for the same fuel. Properties such as the front speed and the stability of the reaction front will be investigated over a range of different parameter values.

A mathematical model of Bieber Fever: The most infectious disease of our time?

Dr Robert Smith?
Mathematics
The University of Ottawa
rsmith43@uottawa.ca
3:40 pm Monday

Recently, an outbreak of Bieber Fever has blossomed into a full pandemic, primarily among our youth. This disease is highly infectious between individuals and is also subject to external media pressure, further strengthening the infection. Symptoms include time-wasting, excessive purchasing of useless merchandise and uncontrollable crying and/or screaming. We develop a mathematical model to describe the spread of Bieber Fever, whereby individuals can be susceptible, Bieber-infected or bored of Bieber. We analyse the model in both the presence and the absence of media, and show that it has a basic reproductive ratio of 24, making it perhaps the most infectious disease of our time. In the absence of media, Bieber Fever can still propagate. However, when media effects are included, Bieber Fever can reach extraordinary heights. Even an outbreak of Bieber Fever that would otherwise burn out (driven by fans becoming bored within two weeks) can still be sustained if media events are staggered. Negative media can rein in oversaturation, but continuous negative media (the Lindsay Lohan effect) is the only way to end Bieber Fever. It follows that tabloid journalism may be our last, best hope against this fast-moving and highly infectious disease. Otherwise, our nations children may be in a great deal of trouble.

Generalised Compact Finite Difference Methods

Mr Andrew Stephan†
MATH/STAT
USYD
andrews@maths.usyd.edu.au
10:20 am Tuesday

Compact finite difference methods are general Pade' schemes that offer a high order low bandwidth alternative to standard finite difference methods for the approximation of (most commonly) the first and second derivatives, with more complicated linear differential operators built by taking the appropriate linear combination of the derivative schemes. In this talk extensions of the compact methods are developed for general linear differential operators of any order resulting in an approximation that has a smaller bandwidth and generates a smaller system for the same order truncation error. Mimicking the procedure of Lele (1990), sub-optimal order schemes are also generated to improve the spectral resolution characteristics of the derived approximation. Applications to magnetohydrodynamics are discussed.

Thin-film flow in helically-wound channels with small torsion.

Dr Yvonne Stokes
School of Mathematical Sciences
The University of Adelaide
yvonne.stokes@adelaide.edu.au
12:40 pm Tuesday

The study of flow in open helically-wound channels has application to many natural and industrial flows. We will consider laminar flow down helically-wound channels of rectangular cross section and with small torsion, in which the fluid depth is small. Assuming a steady-state flow that is independent of position along the axis of the channel, the flow solution may be determined in the two-dimensional cross section of the channel. A thin-film approximation yields explicit expressions for the fluid velocity in terms of the free-surface shape. The latter satisfies an interesting non-linear ordinary differential equation that, for a channel of rectangular cross section, has an analytical solution. The predictions of the thin-film model are shown to be in good agreement with much more computationally intensive solutions of the small-helix-torsion NavierStokes equations. This work has particular relevance to spiral particle separators used in the minerals processing industry.

Metastability in Dynamical Systems

Ms Robyn Stuart†, Gary Froyland, Phil Pollett
School of Mathematics and Statistics
University of New South Wales
r.stuart@unsw.edu.au
5:00 pm Monday

We explore the concept of metastability in open dynamical systems. We look at the conditional probability of trajectories remaining in some set, and consider the maximum conditional probability over all bounded measure subsets of the state space. For closed systems, this maximum is controlled by the second largest eigenvalue of the discretised Perron-Frobenius operator, and is strongly related to the mixing time. We demonstrate an extension of these bounds to open systems. We also discuss the idea of time-reversible dynamics in open dynamical systems, and applications to ocean dynamics.

Lie Markov Models and why they matter to phylogenetics

Dr Jeremy Sumner, Jeremy Sumner, Jesus Fernandez-Sanchez, Peter Jarvis
School Mathematics and Physics
University of Tasmania
jsumner@utas.edu.au
5:20 pm Wednesday

A continuous-time Markov chain can be constructed as either a homogenous or inhomogeneous process. If homogeneity is assumed, the resulting chain is formulted by specifying time-independent rates of substitutions between states in the chain. In applications, there are usually extra constraints on the rates, depending on the situation. If a model is formulated in this way, it is possible to generalise and allow for an inhomogeneous process, with time-dependent rates satisfying the same constraints. It is then then useful to require that there exists a homogeneous average of this inhomogeneous process within the same model. This leads to the definition of Lie Markov Models. These models from Lie algebras and hence concepts from Lie group theory are central to their derivation.

We will discuss why the special properties of Lie Markov Models are important in phylogenetic applications. In particular, we will discuss how the most popular model in current use, the general-time reversible model, fails to be a Lie Markov model and why this matters. We will also present a full hierarchy of Lie Markov models for DNA evolution that are consistent with the grouping of nucleotides into purines and pyrimidines.

Thermomagnetic and sedimentation effects on convection in ferrofluid: theory and experiment

A/Prof. Sergey Suslov, Aleksandra A. Bozhko, Gennady F. Putin, Alexander S. Sidorov
Mathematics
Swinburne University of Technology
ssuslov@swin.edu.au
10:20 am Tuesday

We investigate theoretically and experimentally flows arising in a differentially heated verftical layer of high-Prandtl-number fluid. It is well known that when Grashof number characterising buoyancy increases the basic cubic flow velocity profile becomes unstable with respect to thermogravitational waves propagating vertically. However linear stability studies of a similar flow of magnetopolarizable nanosuspensions (ferrofluids) placed in a uniform magnetic field perpendicular to a fluid layer predicted the existence of a new type of instability, oblique waves. The existence of such waves has now been confirmed experimentally. Perturbation energy analysis has been used to determine the physical nature of the observed instability patterns and quantitatively distinguish between thermogravitational and thermomagnetic waves. We also report and discuss theoretically a strong influence of sedimentation of solid particles on the flow structure.

Outcomes of Binary Scattering at High Energies

Dr Winston Sweatman
Massey University (Albany)
w.sweatman@massey.ac.nz
10:00 am Monday

This talk considers gravitational few-body scattering involving binary point masses. Different outcomes occur a result of such encounters. We explore these for the case of high total energy using theoretical and numerical approaches.

Pricing to Accelerate Demand Learning in Dynamic Assortment Planning

Masoud Talebian, Natashia Boland, Martin Savelsbergh
University of Newcastle
Masoud.Talebian@newcastle.edu.au
12:40 pm Thursday

Retailers, from fashion stores to grocery stores, have to decide what range of products to offer (assortment planning) and what prices to charge (price optimization). New business trends, such as mass customization and shorter product life cycles, make predicting demand more difficult, which in turn complicates assortment planning and price optimization. We propose and study a stochastic dynamic programming model for simultaneously making assortment and pricing decisions that incorporates demand learning using Bayesian updates. Analytical as well as computational results obtained using the model demonstrate the value of demand learning and the benefits of using pricing to accelerate demand learning and provide managerial insights that may help improve a retailer's profitability.

A Microeconomic Model for Journal Revenue Sourcing

Prof. Peter Taylor, Pham Le, Catherine Phillips
Mathematics and Statistics
University of Melbourne
p.taylor@ms.unimelb.edu.au
4:40 pm Monday

Recently there has been considerable pressure on journal publishers to allow open access to papers. The United States National Institutes of Health, the United Kingdom Government, via the Finch Report, and our own National Health and Medical Research Council have all mandated that the research that they fund must be published with open access. The Autralian Research Council is currently considering whether it will institute a similar mandate.

Open access comes in two flavours: 'Gold' open access, where papers are made freely available by the publisher from the date of publication upon payment of a fee by the authors, and 'Green' open access, where papers are made available on an institutional repository when some time has elapsed after publication.

If we take it as given that journals have a role to play in 'certifying' papers via the refereeing process and improving them via both the refereeing and copy-editing process, we need to be able to answer the question as to where journals should get their revenue from. The possibilities are readers, via subscriptions, or authors, via publication charges.

In this talk, I shall describe some work that we have been doing as part of a student vacation project. We started with a model proposed by Jeon and Rochet* and modified some of their assumptions so that they became more realistic. We developed both system optimal solutions and solutions that are compatible with journal publishers acting selfishly.

*Doh-Shin Jeon and Jean-Charles Rochet, The Pricing of Academic Journals: A Two-Sided Market Perspective, American Economic Journal: Microeconomics 2 (May 2010): 222255.

Markov chains with interval transition probabilities

Miss Mingmei Teo†, Nigel Bean, Joshua Ross
School of Mathematical Sciences
University of Adelaide
mingmei.teo@student.adelaide.edu.au
10:40 am Wednesday

There are many situations when we are unable to obtain precise values for our model parameters. Thus, sensitivity analysis is often performed which allows us to explore the consequences of our parameter choices. To try and avoid the need for sensitivity analysis, we seek to develop methods that incorporate the uncertainty in our model through the use of intervals. I will discuss a method for bounding function values given interval input variables to account for the uncertainty of our model parameters. Then, I will proceed to illustrate the method using interval transition probabilities in a Markovian model of population dynamics to calculate the time to population extinction.

Using calculus of variations to model polymer chains with non-circular cross sections

Dr Ngamta Thamwattana, Alexander Gerhardt-Bourke
School of Mathematics and Applied Statistics
University of Wollongong
ngamta@uow.edu.au
10:20 am Thursday

Here, we model polymer chains with non-circular cross sections by considering the free energy density as a general functional of the curvature, torsion and twist angle of a curve in three dimensional space. Through calculus of variations, equilibrium conformation equations are obtained by minimising the free energy functional. In this talk, these equations are used to analyse helical and twisted elastic ribbons.

Geographically clustering New Zealand electorates in the 1893 general election using data describing gender and voter turnout; an application of the Aggregate Association Index

Mr Duy Tran†, Eric Beh, Irene Hudson
School of Mathematical and Physical Sciences
University of Newcastle
duytungtran@yahoo.com
2:40 pm Wednesday

The analysis of aggregate data, or marginal information, for contingency tables is an increasingly important area of statistics. This is, in part, due to confidentiality issues concerned with the study and the way the data is presented or collected. As a result, the availability of only aggregate data makes it difficult to draw conclusions about the association between categorical variables. For categorical data analysts, this issue is of growing concern, especially for those dealing with the aggregate analysis of a single, or stratified, 2x2 tables.

One way to analyse the aggregate data is to use the Aggregate Association Index (AAI). This index quantifies the likelihood of a statistically significant association existing between two dichotomous variables given only the marginal information. The original index was developed for the analysis of a single 2x2 table. Hence, the purpose of this discussion is to use the features of the AAI and its extensions to geographically identify clusters of electorates that have homogenous association structures between gender and voter turnout.

Keywords: Aggregate data, 2x2 tables, Aggregate Association Index

A New Parallel Algorithm for Solving Tri-diagonal Systems

Minh Tran†, Minh Tran
School of Computer Science, Engineering and Mathematics
Flinders University
tran0208@flinders.edu.au
3:40 pm Wednesday

We present a new algorithm for the parallel solution of tridiagonal systems. It has computational complexity $O(n \ln n)$ and is amenable to parallel implementation in $\ln n$ threads. Unlike the Thomas algorithm is does not rely on diagonal dominance of the system to ensure convergence, in fact, we prove that if the original matrix is invertible then our algorithm will produce a solution.. The algorithm was developed for our work on electrochemical modelling of lithium ion batteries and we show the application of the method both to this and other tridiagonal systems.

Solving geodesic problems on a sphere with spherical splines

A/Prof. Thanh Tran
School of Mathematics and Statistics
The University of New South Wales
thanh.tran@unsw.edu.au
5:00 pm Wednesday

We discuss the use of spherical splines in solving various equations on a sphere with application in geoscience, namely the Laplace-Beltrami equation, hypersingular integral equation, and shallow water equations. Fast solution techniques will also be discussed.

Velocity-jump processes with proliferation

Miss Katrina Treloar†, Matthew Simpson, Scott McCue
School of Mathematics
Queensland University of Technology
katrina.treloar@connect.qut.edu.au
12:20 pm Wednesday

Cell invasion involves a population of cells that migrate along a substrate and proliferate to a carrying capacity density. These two processes, combined, lead to invasion fronts that move into unoccupied tissues. Traditional modelling approaches based on reaction-diffusion equations cannot incorporate individual-level observations of cell velocity, as information propagates with infinite velocity according to these parabolic models. In contrast, velocity-jump processes allow us to explicitly incorporate individual-level observations of cell velocity, thus providing an alternative framework for modelling cell invasion. Here, we introduce proliferation into a standard velocity–jump process and show that the standard model does not support invasion fronts. Instead, we find that crowding effects must be explicitly incorporated into a proliferative velocity-jump process before invasion fronts can be observed. Our observations are supported by numerical and analytical solutions of a novel coupled system of partial differential equations, including travelling wave solutions, and associated random walk simulations.

Complex-variable methods for surface-tension-driven viscous flows in two-dimensional multiply-connected domains

Mr Hayden Tronnolone†, Yvonne Stokes, Darren Crowdy
School of Mathematical Sciences
University of Adelaide
hayden.tronnolone@adelaide.edu.au
5:20 pm Monday

Microstructured optical fibres (MOFs) are a design of optical fibre that consist of a series of air channels positioned inside a thread of material. A MOF may be constructed by first extruding molten material through a die in order to produce a preform having the required pattern of air channels; the preform is then heated and pulled to yield a fibre. While this method provides great flexibility, the fluid flow that arises during manufacture can deform the air channels, which can render the fibre useless. I aim to increase understanding of the flow and its impact on geometry, which will lead to better control of deformations. I will discuss a complex-variable spectral method for modelling two-dimensional Stokes flow in a multiply-connected domain. In particular, I will discuss the use of conformal maps to describe the boundaries and their evolution over time, and methods for constructing these maps.

An iterative shrinking metric f-projection method for finding a common fixed point of a quasi strict f-pseudo-contraction and a countable family of firmly nonexpansive mappings and applications in Hilbert spaces

Dr Kasamsuk Ungchittrakool, Duangkamon Kumtaeng
Department of Mathematics
Naresuan University
kasamsuku@nu.ac.th
12:20 pm Thursday

In this paper, we create some new ideas of mappings called quasi strict f-pseudo-contractions. Moreover, we also find the significant inequality related to such mappings and firmly nonexpansive mappings in the framework of Hilbert spaces. By using the ideas of metric f-projection, we propose an iterative shrinking metric f-projection method for finding a common fixed point of an quasi strict f-pseudo-contraction and a countable family of firmly nonexpansive mappings. In addition, we provide some applications of the main theorem to finding a common solution of fixed point problems and generalized mixed equilibrium problems as well as other related results.

Travelling spots in a three-component FitzHugh-Nagumo equation

Dr Petrus van Heijster, B. Sandstede (Brown University)
QUT
petrus.vanheijster@qut.edu.au
10:00 am Wednesday

In this talk, I will construct stationary spots in a phenomenological model for gas-discharge. Next, I will study the bifurcation of these spots to travelling spots. Since there are also several Hopf instabilities, we have to make sure that the drift bifurcation is the primary instability. Besides the location of bifurcation point, we will also determine the criticality of the bifurcation, the speed and shape of the bifurcating travelling spot. This work is a combination of analytic results, formal results and numerical results.

Combining Mathematics and Electrophysiology to Understand Bursting in Pituitary Cells

Mr Theodore Vo†, Joel Tabak, Richard Bertram and Martin Wechselberger
School of Mathematics and Statistics
University of Sydney
theodore.vo@sydney.edu.au
12:40 pm Wednesday

It has been shown that large conductance potassium (BK) current tends to promote bursting in pituitary cells. This requires fast activation of the BK current, otherwise it is inhibitory to bursting. In this work, we combine geometric singular perturbation theory and the dynamic clamp technique to answer the question of why BK activation must be fast in order to promote bursting. In particular, we show (mathematically and experimentally) that the bursting arises from a slow passage through a dynamic Hopf bifurcation.

A model of asymmetric cell division: implications for tumour biology and some new non-local calculus

Prof. Graeme Wake, Ali Ashher Zaidi, Bruce van-Brunt
Institute of Natural and Mathematical Sciences
Massey University Auckland
g.c.wake@massey.ac.nz
10:20 am Wednesday

Cells dividing asymmetrically are essential for generating diverse cell types during development. The capacity for symmetric stem-cell self-renewal may confer developmental plasticity, increased growth and enhanced regenerative capacity; however, it may also confer an inherent risk of cancer. When the machinery that regulates asymmetric divisions is disrupted, however, these cells begin dividing symmetrically and form tumours. This needs underpinning rigour to understand the dynamics of cancer-cell growth and regulation of cell-growth. A new model is needed of cell-growth with asymmetrical division (two or more daughter cells of different sizes (usually DNA content)) from a single division-event. This model must capture the key features from earlier models with symmetrical cell-division, where the cell-size distribution tends asymptotically to one of constant shape when the cohort is not disturbed; this being a well-known observation. This is called a steady-size-distribution (SSD).

A model is proposed which does this for different types of cellular evolution and amounts to a hyperbolic integro-differential equation. Separated solutions answer the question of SSD behaviour and the time-constant can be a principal eigenvalue of a singular first-order integro-first-order ODE. More general questions arise as to whether these solutions are attracting with time. These ideas will be reviewed in this lecture.

Global Optimization Methods for the Discrete Network Design Problem

Dr Shuaian Wang, Qiang Meng, Hai Yang
School of Mathematics and Applied Statistics
University of Wollongong
wangshuaian@gmail.com
10:20 am Thursday

We address the discrete network design problem (DNDP) with multiple capacity levels, or multi-capacity DNDP for short, which determines the optimal number of lanes to add to each candidate link in a road network. We formulate the problem as a bi-level programming model, where the upper level aims to minimize the total travel time via adding new lanes to candidate links and the lower level is a traditional Wardrop user equilibrium (UE) problem. We propose two global optimization methods by taking advantage of the relationship between UE and system optimal (SO) traffic assignment principles. The first method, termed as SO-relaxation, exploits the property that an optimal network design solution under SO principle can be a good approximate solution under UE principle, and successively sorts the solutions in the order of increasing total travel time under SO principle. Optimality is guaranteed when the lower bound of the total travel time of the unexplored solutions under UE principle is not less than the total travel time of a known solution under UE principle. The second method, termed as UE-reduction, adds the objective function of the Beckmann-McGuire-Winsten transformation of UE traffic assignment to the constraints of the SO-relaxation formulation of the multi-capacity DNDP. This constraint is convex and strengthens the SO-relaxation formulation. We also develop a dynamic outer-approximation scheme to make use of the state-of-the-art mixed-integer linear programming solvers to solve the SO-relaxation formulation. Numerical experiments based on a two-link network and the Sioux-Falls network are conducted.

Restricted normal cones and the method of alternating projections

Dr Xianfu Wang, Heinz Bauschke, Russel Luke, Hung Phan
Mathematics
University of British Columbia
shawn.wang@ubc.ca
11:40 am Thursday

The method of alternating projections (MAP) is a common method for solving feasibility problems. Little was known about the behavior of the MAP in the nonconvex case until 2009, when Lewis, Luke, and Malick derived local linear convergence results provided that a condition involving normal cones holds and at least one of the sets is superregular. However, their results failed to capture very simple classical convex instances.

In this talk, we extend and develop the Lewis-Luke-Malick framework so that not only any two linear subspaces but also any two closed convex sets whose relative interiors meet are covered. We also allow for sets that are more structured such as unions of convex sets. The key tool required is the restricted normal cone, which is a generalization of the classical Mordukhovich normal cone.

Canards and Excitability

A/Prof. Martin Wechselberger, John Mitry (USyd), John Rinzel (NYU)
School of Mathematics and Statistics
University of Sydney
wm@maths.usyd.edu.au
10:20 am Thursday

The notion of excitability was first introduced in an attempt to understand firing behaviours of neurons. It was Alan Hodgkin who identified three basic types (classes) of excitable axons – integrator, resonator and differentiator – distinguished by their different responses to injected steps of currents of various amplitudes.

Pioneered by Rinzel and Ermentrout, bifurcation theory explains repetitive (tonic) firing patterns for adequate steady inputs in integrator (type I) and resonator (type II) neuronal models. In contrast, the dynamic behaviour of differentiator (type III) neurons cannot be explained by standard dynamical systems theory. This third type of excitable neuron encodes a dynamic change in the input and leads naturally to a transient response of the neuron.

In this talk, I will show that Canard Theory is well suited to explain the nature of transient responses of (type II and III) neurons due to dynamic (smooth) inputs. The key observation is that canards are still well defined in non-autonomous multiple time-scales dynamical systems. Thus canards have the potential to significantly shape the nature of solutions in non-autonomous multiple time-scales systems. I will highlight this important point of view.

Set-valued Average Value at Risk

Benjamin Weißing†, Frank Heyde, Andreas H. Hamel, Birgit Rudloff
Naturwissenschaftliche Fakultt II, Institut fr Mathematik, Arbeitsgruppe Optimierung und Stochastik
Martin-Luther-University Halle-Wittenberg
benjamin.weissing@mathematik.uni-halle.de
5:00 pm Monday

Artzner et al. (1999) pointed out, that the widely used risk measure V@R (Value at Risk) has a major shortcoming describing the risk of financial positions due to its lack of subadditivity. They provided a class of measures of risk, which they found to be better suited for the evaluation of risk and named them coherent. An important example is the AV@R (Average Value at Risk), otherwise known as conditional value at risk or expected shortfall, which is defined in terms of the V@R but complies with the coherence-axioms. In their 2010-paper Andreas Hamel and Frank Heyde consider financial assets, which are evaluated in terms of more than one so-called numraires, and consequently modelled as random vectors instead of random variables. Real valued risk measures measure the risk of a financial position by assigning to the position the minimal amount of capital which is required to be invested in a risk-free manner in order to compensate for the risk of the position; whereas the set-valued measures of risk provided by Hamel/Heyde assign the set of all positions which, if added to the initial position, make the investment acceptable. This approach makes it possible to take into account market frictions such as transaction costs.

The aim of the talk is to present a primal and a dual description of the set-valued AV@R which fits in the framework of set-valued measures of risk developed by Hamel/Heyde (2010) and the extension to conical market models (Hamel/Heyde/Rudloff (2011)). The primal AV@R is derived by extending the minimization-problem-representation of the real-valued AV@R (Rockafellar/Uryasev (2000)) to the set-valued setting; the set-valued dual version is a translation of the real valued dual description of the AV@R to the set-valued case. Using the set-valued version of Fenchel–Rockafellar's duality theorem (Hamel (2011)) the equivalence of the given primal and dual versions will be shown.

The sparse grid combination technique for multi-dimensional problems

Matthias Wong†
MSI
Australia National University
matthias.wong@anu.edu.au
4:00 pm Monday

The sparse grid combination technique proposed in "A combination technique for the solution of sparse grid problems" Griebel (1992) proved immensely useful in multidimensional applications. The combination technique approximates a high-resolution solution of a numerical problem using several low-resolution "component solutions" which can be calculated efficiently. This overcomes the curse of dimensionality to an extent. The mathematical theory of the combination technique is not, however, well developed. In applications the combination technique displays a wider range of phenomenon than traditional analysis suggests. Moreover, in applications, the combination technique has been developed beyond the original error analysis. In this presentation, we employ "Adaptive sparse grids" by Hegland (2002) and define the combination technique to "catch up" with existing applications. We derive a new error expansion of combination technique and an corollary error bound. This new approach pushes forward the theoretical understanding of the combination technique. Prior knowledge of the technique is not assumed.

Generation and Control of Solitons using Various Nematic Geometries and Regimes

A/Prof. Annette Worthy, G. Assanto, A. Minzoni and N. Smyth
Maths and Stats
Wollongong
annie@uow.edu.au
1:00 pm Monday

A mathematical treatise of recent experimental work on the generation and control of optical solitons in the nonlinear nonlocal nematic media will be discussed. It will be shown that having an additional localized voltage to form various suitable regimes causes the director or nematic to have different orientations with the cell. Some geometries that will be studied are the rectangular cross section, circular and elliptical regions.

Using asymptotic methods along with the nematicon being is largely independent of functional form of its prole, it is shown how the beam evolves. It will be revealed that the nematicon sheds radiation whereby the velocity and position decoupled from its width and amplitude oscillations. Further, due to the additional geometrics caused by an external applied voltage to the nematic upon twisting the molecules, the resulting polarized self propagating beams distorts and refracts.

The resulting mathematical analysis is quick and efficient and is shown to give excellent agreement to both experimental work and numerical simulations.

Numerical study of oscillatory Couette flow in rarefied gas

Miss Ying Wan Yap†, Yong Shi, John E. Sader
Department of Mathematics and Statistics
University of Melbourne
yingwan88@gmail.com
3:40 pm Monday

Gas flows generated by nanoscale devices can achieve oscillation frequencies comparable to the intermolecular collision frequency. Modeling these flows often requires the use of kinetic theory, because such operation invalidates the use of standard continuum treatments. The Bhatnagar-Gross-Krook (BGK) kinetic model approximates the effect of molecular collisions as a relaxation process, and is often used to describe non-equilibrium gas flows. In this talk, I will present a numerical study of oscillatory Couette flow to obtain benchmark solutions using the BGK model. Applicability of the lattice Boltzmann method to such flow is also assessed using these benchmark solutions.

An overview of estimation for ordinal log-linear models

Ms Sidra Zafar†, Beh, E.J., Hudson, I.L.
Mathematical and Physical Sciences
University of Newcastle
spunkysid@gmail.com
3:00 pm Wednesday

Ordinal log-linear models are amid the most widely used and powerful techniques to model association among the ordinal variables in categorical data analysis. Traditionally, the parameters form such models are estimated using iterative algorithms (such as the Newton-Raphson method, and iterative proportional fitting). More recent advances have suggested a method of non-iterative estimation that works equally well for the estimation of linear-by-linear association parameter in an ordinal log-linear model for a two-way table. This presentation will highlight the development of iterative and non-iterative techniques commonly used to estimate the parameters from two-dimensional ordinal log-linear models and provide an overview of how the growing number of non-iterative estimation techniques fit into the problem.

10 Delegates

Miss Nurul Syaza Abdul Latif	n.s.abdullatif@massey.ac.nz
Muteb Alharthi	mraah761@uowmail.edu.au
Dr David Allingham	david.allingham@newcastle.edu.au
Mr Fehaid Alshammari	fehaid.alshammari@student.qut.edu.au
Bob Anderssen	bob.anderssen@csiro.au
Dr Fran Aragon	fran.aragon@newcastle.edu.au
Mr Julian Back	j.back@student.qut.edu.au
Mr Alexander Badran	alexjbadran@gmail.com
Dr Boris Baeumer	bbaeumer@maths.otago.ac.nz
Dr Rowena Ball	rowena.ball@anu.edu.au
Dr Luigi Barone	lbarone@solveitsoftware.com
Professor Andrew Bassom	tania.blackwell@uwa.edu.au
Heinz Bauschke	bauschke@mac.com
Professor Nigel Bean	nigel.bean@adelaide.edu.au
Dr Alona Ben-Tal	a.ben-tal@massey.ac.nz
Sangeeta Bhatia	17545059@student.uws.edu.au
Rachellle Binny	rachelle.binny@pg.canterbury.ac.nz
Dr Andrew Black	andrew.black@adelaide.edu.au
Professor Bill Blyth	bill.blyth@rmit.edu.au
John Boland	john.boland@unisa.edu.au
Professor Natashia Boland	natashia77@gmail.com
Professor Jon Borwein	jon.borwein@gmail.com
Samsung Professor Stephen Boyd	boyd@stanford.edu
Dr Michael Brideson	Michael.Brideson@utas.edu.au
Professor Phil Broadbridge	p.broadbridge@latrobe.edu.au
Professor Patrick Browne	patrick.browne@usask.ca
Ms Rachel Bunder	rachelbunder@gmail.com
Regina Burachik	regina.burachik@unisa.edu.au
Meng Cao	meng.cao@adelaide.edu.au
Dr Debadi Chakraborty	debadi.chakraborty@unimelb.edu.au
Mr Alexander Chalmers	acha5264@uni.sydney.edu.au
Mr Hadi Charkhgard	h.charkhgard@gmail.com
Mr Salman Cheema	salman.cheema@uon.edu.au
Sue Chen	sue.chen87@gmail.com
Chen Chen	chen.chen@adelaide.edu.au
Lisa Cheree Mayo	sef.mathsfinance@qut.edu.au
Mr Josh Chopin	chojp002@mymail.unisa.edu.au
Dr Simon Clarke	simon.clarke@monash.edu.au
Mr Jason Cosgrove	Jason.Cosgrove@utas.edu.au
Adelle Coster	A.Coster@unsw.edu.au
Professor Darren Crowdy	d.crowdy@imperial.ac.uk
Peter Cudmore	peter.cudmore@uqconnect.edu.au
Mr Michael Dallaston	michael.dallaston@qut.edu.au
Mr Kale Davies	kale.davies@student.adelaide.edu.au
Dr Frank de Hoog	Frank.dehoog@csiro.au
Dr Michael Deakin	michael.deakin@monash.edu
Kathryn Deutscher	krdeutscher@students.latrobe.edu.au
Professor Keith Devlin	kdevlin@stanford.edu
Isaac Donnelly	i.donnelly@unsw.edu.au
Dr Jerome Droniou	jerome.droniou@monash.edu
Prof Andrew Eberhard	andy.eb@rmit.edu.au
Professor Matthias Ehrgott	m.ehrgott@auckland.ac.nz
Tarek Elgindy	tarek.elgindy@csiro.au
Mr Adam Ellery	a.ellery@qut.edu.au
Mr Darren Engwirda	d.engwirda@maths.usyd.edu.au
Professor Bard Ermentrout	ermentrout@gmail.com
Dr Mark Fackrell	fackrell@unimelb.edu.au
Mr David Farmer	dfar6459@gmail.com
Troy Farrell	t.farrell@qut.edu.au

Nicholas James Fewster-Young	nicholas@unsw.edu.au
Professor Joerg Fliege	j.fliege@soton.ac.uk
Mr Brendan Florio	brendan.florio@graduate.uwa.edu.au
Larry Forbes	Larry.Forbes@utas.edu.au
Mr James Foster	james.forster@uon.edu.au
Dr Federico Frascoli	ffrascoli@gmail.com
Gary Froyland	g.froyland@unsw.edu.au
Professor David Gao	d.gao@ballarat.edu.au
Mr Bennet Peter Gardiner	bennett.gardiner@qut.edu.au
Christian Gerhards	gerhards4@gmx.de
Dr Asim Ghous	asim.ghous@ases.co
James Gilmore	james.gilmore@unsw.edu.au
Professor Chris Glasbey	chris@bioss.ac.uk
Cathy Gray	catheryn.gray@unsw.edu.au
Dr Bronwyn Hajek	Bronwyn.Hajek@unisa.edu.au
Mr Brendan Harding	brendan.harding@anu.edu.au
Ms Kristen Harley	kristen.harley@qut.edu.au
Prof John Harper	john.harper@vuw.ac.nz
Sharleen Harper	Sharleen.Harper@niwa.co.nz
Laura Hattam	Laura.Hattam@monash.edu.au
Dr Michael Haythorpe	michael.haythorpe@flinders.edu.au
Professor John Hearne	john.hearne@rmit.edu.au
Markus Hegland	markus.hegland@anu.edu.au
Mrs Hala Hejazi	hala.hejazi@student.qut.edu.au
Professor Bruce Henry	b.henry@unsw.edu.au
Roslyn Hickson	Roslyn.Hickson@newcastle.edu.au
Professor Graeme Hocking	G.Hocking@murdoch.edu.au
Mr Andrew Holder	abh920@uowmail.edu.au
Mr David Horsley	david.horsley@utas.edu.au
Philip Howes	howespt@gmail.com
Professor Irene Hudson	irenelena.hudson@gmail.com
Majda Idlango	majda.idlango@rmit.edu.au
Dr David Ivers	david.ivers@sydney.edu.au
Mr Aidin Jalilzadeh	aidin@maths.otago.ac.nz
David Jarvis	david.jarvis@adelaide.edu.au
Dr Petrus Johannes van Heijster	petrus.vanheijster@qut.edu.au
Miss Reena Kapoor	reena.kapoor@uon.edu.au
Dr Pavlos Kassotakis	pavlos1978@yahoo.com
Ms Simranjit Kaur	simranjit.kaur@uon.edu.au
Dr Reiichiro Kawai	reiichiro.kawai@maths.usyd.edu.au
Yalcin Kaya	yalcin.kaya@unisa.edu.au
Valeriy Khakhutskyy	khakhutv@in.tum.de
David Khoury	david.khoury@student.unsw.edu.au
Professor Hanna Kokko	hanna.kokko@anu.edu.au
Christoph Kowitz	kowitz@in.tum.de
Dr Poom Kumam	poom.kum@kmutt.ac.th
Wiyada Kumam	wiyada.kum@mail.rmutt.ac.th
Dr Frances Kuo	f.kuo@unsw.edu.au
Mr Michael Lachut	M.Lachut@ms.unimelb.edu.au
Daniel Ladiges	dladiges@ms.unimelb.edu.au
Carlo Laing	c.r.laing@massey.ac.nz
Dr Bishnu Lamichhane	” Bishnu.Lamichhane@newcastle.edu.au”
Dr Gobert Lee	gobert.lee@flinders.edu.au
Mr David Lee	david.lee@monash.edu.au
Mrs Lucy Leigh	lucy.leigh@newcastle.edu.au
Dr Paul Leopardi	paul.leopardi@anu.edu.au
Andreas Loehne	andreas.loehne@mathematik.uni-halle.de
Mr Stephen Maher	stephen.maher@unsw.edu.au
Dr Robert Marangell	robert.marangell@sydney.edu.au
Professor Tim Marchant	joell@uow.edu.au
Stphane Marouani	stephane.marouani@mathworks.com.au

Dr Dmytro Matsypura	dmytro.matsypura@sydney.edu.au
Dr James McCaw	jamesm@unimelb.edu.au
Assoc Prof Scott McCue	scott.mccue@qut.edu.au
Professor Robert McKibbin	R.McKibbin@massey.ac.nz
Mr Shawn Means	k.harsant@auckland.ac.nz
Assoc Prof Geoff Mercer	Geoff.Mercer@anu.edu.au
Dr Mike Meylan	Mike.Meylan@newcastle.edu.au
Prof Stanley Miklavcic	Stan.Miklavcic@unisa.edu.au
Mr John Mitry	john.mitry@gmail.com
John Murray	j.murray@unsw.edu.au
Mary Myerscough	mary.myerscough@sydney.edu.au
Mr Meksianis Zadrak Ndii	meksand@gmail.com
Assoc Prof Mark Nelson	mnelson@uow.edu.au
Miss Giang Nguyen	giang.nguyen@adelaide.edu.au
Dr Dirk Nuyens	dirk.nuyens@cs.kuleuven.be
Dr Sheehan Olver	Sheehan.Olver@sydney.edu.au
Dr Dion O'Neale	d.oneale@irl.cri.nz
Martin Paesold	21102578@student.uwa.edu.au
Michael Page	michael.page@monash.edu
Mr Sanjoy Paul	e.carey@adfa.edu.au
Catherine Penington	c.penington@student.unimelb.edu.au
Mr Ravidra Pethiyagoda	ravidra.pethiyagoda@qut.edu.au
Narin Petrot	narinp@nu.ac.th
Professor Graeme Pettet	g.pettet@qut.edu.au
Dr Collin Phillips	collin.phillips@sydney.edu.au
Dr Julia Piantadosi	julia.piantadosi@unisa.edu.au
Dr Michael Plank	michael.plank@canterbury.ac.nz
Professor Somyot Plubtieng	somyotp@nu.ac.th
Mr Mohsen Reisi	m.reisi@gmail.com
Assoc Prof Anthony Roberts	apr@maths.uq.edu.au
Professor Mike Roberts	m.g.roberts@massey.ac.nz
Mr Michael Rose	Michael.rose@newcastle.edu.au
Joshua Ross	joshua.ross@adelaide.edu.au
Joshua Ross	joshua.ross@adelaide.edu.au
Professor Osamu Saeki	saeki@imi.kyushu-u.ac.jp
Dr Galyna Safonova	galyna.saf@gmail.com
Mr Fehaid Salem L Alshammari	fashmmri@yahoo.com
Professor Martin Savelsburgh	Martin.Savelsburgh@newcastle.edu.au
Dr Borislav Savkovic	b.savkovic@unsw.edu.au
Mr Timothy Schaerf	timothy.schaerf@sydney.edu.au
Christopher Schneider	Martin.Seydenschwanz@uni-jena.de
Miss Lisa Schultz	lisa.schultz@mymail.unisa.edu.au
Mr Luke Sciberras	lws31@uowmail.edu.au
Martin Seydenschwanz	martin.seydenschwanz@uni-jena.de
Jason Sharples	j.sharples@adfa.edu.au
Mr Yang Shen	skyshen87@gmail.com
Ms Chaitanya Shettigara	chaitanya.shettigara@anu.edu.au
Associate Professor Harvi Sidhu	h.sidhu@adfa.edu.au
Dr Matthew Simpson	matthew.simpson@qut.edu.au
Associate Professor Brailey Sims	Brailey.Sims@newcastle.edu.au
Mr Robert Smith	rsmith43@uottawa.ca
Kim Somfleth	kim.somfleth@internode.on.net
Andrew Stephan	andrews@maths.usyd.edu.au
Dr Yvonne Stokes	yvonne.stokes@adelaide.edu.au
Ms Robyn Stuart	r.stuart@unsw.edu.au
Dr Jeremy Sumner	Karen.Bradford@utas.edu.au
Dr Sergey Suslov	ssuslov@swin.edu.au
Dr Winston Sweatman	w.sweatman@massey.ac.nz
Dr Masoud Talebian	Masoud.talebian@newcastle.edu.au
Mr Matthew Tam	matthew.tam@newcastle.edu.au
Prof Peter Taylor	p.taylor@ms.unimelb.edu.au

Miss Mingmei Teo	mingmei.teo@student.adelaide.edu.au
Dr Ngamta Thamwattana	ngamta@uow.edu.au
Quoc Thong Le Gia	qlegia@unsw.edu.au
Mr Du Tung Tran	duytungtran@yahoo.com
Associate Professor Thanh Tran	thanh.tran@unsw.edu.au
Minh Tran	tran0208@flinders.edu.au
Katrina Treloar	sef.mathsfinance@qut.edu.au
Hayden Tronnolone	hayden.tronnolone@adelaide.edu.au
Juliane Turner	Juliane.turner@newcastle.edu.au
Kasamsuk Ungchittrakool	kasamsuk@nu.ac.th
Theodore Vo	theo.m.t.vo@gmail.com
Dr Xuan Vu	xuan.vu@unisa.edu.au
Masato Wakayama	wakayama@imi.kyushu-u.ac.jp
Professor Graeme Wake	g.c.wake@massey.ac.nz
Dr Shuaian Wang	wangshuaian@gmail.com
Dr Shawn Wang	shawn.wang@ubc.ca
Martin Wechselberger	wm@maths.usyd.edu.au
Benjamin Weißing	benjamin.weissing@student.uni-halle.de
Dr Simon Williams	victoria.allen@flinders.edu.au
Matthias Wong	matthias.wong@anu.edu.au
Associate Professor Annette Worthy	annie@uow.edu.au
Ying Wan Yap	yingwan88@gmail.com
Dr Liangjin Yao	liangjin.yao@newcastle.edu.au
Ms Sidra Zafar	Sidra.Zafar@uon.edu.au

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